F.4.4.2.1.3 Cultural Resources

There are no known historical, archaeological, paleontological, or Native American traditional sites in or around the potential storage site. No impacts to cultural resources are expected from ground disturbance, noise, or air emissions during construction or operation of the facility. Consultation with the Tennessee State Historic Preservation Office prior to project implementation is required by Section 106 of the National Historic Preservation Act of 1966. The State Historic Preservation Office may recommend further studies of the potential storage site to verify that no archaeological areas would be disturbed by construction activities (DOE, 1995g).

F.4.4.2.1.4 Aesthetic and Scenic Resources

Construction and operation of a new dry storage facility for foreign research reactor spent nuclear fuel would have similar impact on aesthetic and scenic resources at the Oak Ridge Reservation as the construction of spent nuclear fuel facilities under the Centralization Alternative considered in the Programmatic SNF&INEL Final EIS (DOE, 1995g). The spent nuclear fuel facilities associated with the Centralization Alternative would consist of a series of industrial buildings set within a 36-ha (90-acre) site. The maximum height of the buildings on the site would not exceed 12.8 m (42 ft) above ground level, or two to three stories. Since the buildings would be set into the south face of Pine Ridge, between Pine Ridge and Chestnut Ridge, the site would not be visible from areas outside the Reservation, with the possible exception of a limited section of Gallaher Road on the west side of the Clinch River, looking east along Bear Creek Valley and the Bear Creek Road which is accessible to the public. The site would be screened by appropriate vegetation so that the public views would not be affected. Potential soil erosion and dust generation associated with construction-related activities would be controlled by the implementation of best-management practices. Any visibility impacts from fugitive dust generation by construction-related activities should be insignificant and short term. Facility operations associated with the dry storage of foreign research reactor spent nuclear fuel should not generate any atmospheric emissions which would reduce area visibility.

F.4.4.2.1.5 Geology

For the most part, geologic impacts from construction activities would be limited to soil disturbance; although in some areas, ripping or blasting of limestone, dolomite, or chert layers might be required. No extensive or unique geologic or mineral resources are found in or around the potential storage site, so no geological impacts would be expected (DOE, 1995g). The operation of the new dry storage facility would have no effect on the geologic characteristics at the site.

Because previously undisturbed areas would be used for new construction, some soil impacts from siting a new dry storage facility at the West Bear Creek Valley site would occur as a result of grading. Potential impacts from sediment runoff generated during construction activities would be minimized by implementation of soil erosion and sediment control measures. During operations, impacts to soil resources would be controlled by the planting or landscaping of land surfaces not covered by pavement and buildings (DOE, 1995g).

Major seismic activity and associated mass movement and subsidence are unlikely to occur during the construction or operation because faults in the area have not been active since the late Paleozoic Era (DOE, 1995g).

F.4.4.2.1.6 Air Quality

Nonradiological Emissions: Potential air quality impacts associated with construction include generation of fugitive dust (particulate matter) and smoke from earth moving and clearing operations and emissions from construction equipment. Sources of fugitive dust include:

- transfer of soil to and from haul trucks and storage piles;
- turbulence created by construction vehicles moving over cleared, unpaved surfaces; and
- wind-induced erosion of exposed surfaces.

Construction of this facility would require the clearing of approximately 16 ha (40 acres) of land. However, the overall construction impacts to the ambient air quality of the region should be minimal due to the short duration (3 months to 6 years) of the project. Emissions of sulfur dioxide, nitrogen dioxide, and carbon monoxide are assumed to result entirely from diesel exhaust during the construction process. Respirable particulate matter (e.g., PM_{10}) is assumed to be 64 percent of the total suspended particulates estimated for the construction effort. Additionally, wetting controls are assumed to reduce this amount by 50 percent, which is a very conservative estimate.

Table F-70 presents the air quality impacts associated with the construction of a new dry storage facility at the Oak Ridge Reservation. Additionally, this table shows that the ambient impacts would be minimal and compliance with existing Federal and State ambient air quality standards would not be adversely affected. Therefore, construction activities would not be expected to have any detrimental effect on the health and safety of the general population. The estimated impacts from construction activities were generated using the Environmental Protection Agency regulatory-approved Industrial Source Complex Short-Term Model, Version 2.0, in conjunction with onsite meteorological data from 1991.

Table F-70 Estimated Maximum Concentrations of Criteria Pollutants at the Oak Ridge Reservation Attributable to New Dry Storage Construction

Pollutant	*Averaging Time*	*Ambient Standard*[a]	*Baseline Concentration*[b]	*Construction Activities*
Oak Ridge Reservation Boundary ($\mu g/m^3$)[c]				
• Particulate Matter (PM_{10})[c]	24-hr	150	84.9	0.5450
	Annual	50	0.43	0.0144
• Carbon Monoxide	1-hr	40,000	2,748.0	26.756
	8-hr	10,000	2,290.8	3.345
• Sulfur Dioxide	3-hr	1,300	170.3	2.356
	24-hr	365	55.2	0.345
	Annual	80	1.1	0.006
• Nitrogen Oxide	Annual	100	2.1	0.098

[a] *64 percent of total suspended particulates is considered to be respirable particulate matter (e.g., PM_{10}) for the construction activities. The standard refers to the actual PM_{10} standard.*

[b] *Source: DOE, 1995g*

[c] *To convert to $\mu g/ft^3$, multiply by 0.0283*

Nonradiological emissions are not expected during operation of a new dry storage facility.

Radiological Emissions: No radiological emissions from construction of a new dry storage facility for foreign research reactor spent nuclear fuel are expected. Based on fuel drying and storage operations conducted at Idaho National Engineering Laboratory, potential atmospheric releases from the spent nuclear fuel storage facility would consist of minor amounts of particulate radioactive material and larger amounts of gaseous fission products that could escape from the fuel through cladding defects. The majority of radioactive material responsible for fuel and cask internal surface contamination consists of activation products that plate out on the spent nuclear fuel assemblies during reactor operation. This material is dependent on corrosion of structural materials and generally consists of radionuclides such as ^{58}Co, ^{60}Co, ^{59}Fe, etc. This contamination activity would have to be controlled during the cask opening and fuel handling operations to prevent internal personnel exposures. Proper facility ventilation (designed to provide airflow from areas of low contamination to progressively higher contamination) would help provide contamination control. High-efficiency particulate air filters in the facility exhaust would reduce the airborne effluent quantities of this particulate material to quantities that are well within the prescribed limits.

Cask opening and fuel drying operations may also be responsible for the release of significant amounts of ^{3}H, ^{85}Kr, and minor amounts of ^{129}I. The amounts of these radionuclides released during the cask opening operation depends on the following parameters: (1) the number of spent nuclear fuel clad defects; (2) the spent nuclear fuel material and the diffusion rate of these radionuclides through the fuel matrix for the fuel temperature while in the cask, and (3) the time that the spent nuclear fuel is contained within the cask before opening.

Similarly, for fuel drying operations, the temperature of the drying gas (as well as the parameters discussed above) would cause quantities of ^{3}H, ^{85}Kr, and ^{129}I to be released from the fuel. Charcoal or silver zeolite filters could be used to remove the ^{129}I from the exhaust, but the ^{3}H and ^{85}Kr, being gases, or in a gaseous state for the case of tritiated water, would be exhausted to the atmosphere. During spent nuclear fuel storage small amounts of the gaseous/volatile radionuclides are expected to be released to the environment based on the fuel matrix, clad defects, and storage temperature. Release rates would decrease with storage time due to radioactive decay. It is anticipated that the fuel drying operation would be responsible for the most significant release of these gaseous/volatile radionuclides to the environment.

For this analysis, radiological emissions from the operation of a new dry storage facility were calculated based on the methodology and assumptions described in Appendix F, Section F.6. The radiological consequences of air emissions from the operation of the dry storage facilities at the Oak Ridge Reservation are discussed in Section F.4.4.2.1.11. The annual emission releases from the dry storage facility during receipt and unloading and storage are provided in Section F.6.6.1.

F.4.4.2.1.7 Water Resources

The water usage during construction of a new dry storage facility is estimated to be about 7.75 million l (2 million gal). During operations, annual water consumption would be 2.1 million l (550,000 gal) for receipt and handling and 0.4 million l (109,000 gal) for storage. With an annual average water usage of approximately 3,060 million l (808 million gal) for the Oak Ridge Reservation, these amounts represent no more than a 0.07 percent increase in annual water usage. Therefore, a new dry storage facility would have minimal impact on water resources at the Oak Ridge Reservation.

Best-management practices during construction would prevent sediment runoff or spills of fuels or chemicals. Therefore, construction activities should have no impact on water quality at the Oak Ridge Reservation. The impact on water quality during operations would also be negligible. Existing water treatment facilities at the Oak Ridge Reservation could accommodate any new domestic and process wastewater streams from a new dry storage facility. The expected total flow volumes at the Oak Ridge

Reservation would still be well within the design capacities of treatment systems at the Oak Ridge Reservation. A new dry storage facility would meet National Pollutant Discharge Elimination System limits and reporting requirements, so no impact on the water quality of receiving streams is expected.

F.4.4.2.1.8 Ecology

Terrestrial Resources: Radiation doses received by terrestrial biota from foreign research reactor spent nuclear fuel activities would be expected to be similar to those received by man. Although guidelines have not been established for acceptance limits for radiation exposure to species other than man, it is generally agreed that the limits established for humans are also conservative for other species. Evidence indicates that no other living organisms have been identified that are likely to be significantly more radiosensitive than man. Thus, so long as exposure limits protective of man were not exceeded, no significant radiological impact on populations of biota would be expected as a result of foreign research reactor spent nuclear fuel activities at the West Bear Creek Site (DOE, 1995g).

Under the Centralization Alternative, construction of the potential spent nuclear fuel management facility would result in the disturbance of approximately 36 ha (90 acres) [16 ha (40 acres) if foreign research reactor spent nuclear fuel is considered in isolation], or less than 1 percent of the Oak Ridge Reservation. It is assumed that the area to be disturbed includes construction laydown areas, grading, and new buildings, and that the access road or other rights-of-ways have not been included in the total area to be disturbed. Vegetation within the area of the potential site for the spent nuclear fuel management facility would be destroyed during land clearing activities, but may be mitigated by revegetating with native species where possible. Vegetation cover in this area is predominantly oak-hickory forest or pine-hardwood forest. Both forest types are common on the Oak Ridge Reservation and within the region (DOE, 1995g).

Construction of a new dry storage facility would have some adverse effects on animal populations. Less mobile animals, such as amphibians, reptiles, and small mammals, within the project area would be destroyed during land-clearing activities. Larger mammals and birds in construction and adjacent areas would be disturbed by construction activities and would move to nearby suitable habitat. The long-term survival of these animals would depend on whether the area to which they moved was at or below its carrying capacity. Areas that would be revegetated upon completion of construction would be of minimal value to most wildlife, but might be repopulated by more tolerant species (DOE, 1995g).

The Migratory Bird Treaty Act is primarily concerned with the destruction of migratory birds, as well as their eggs and nests. It could be necessary to survey construction sites for the nests of migratory birds prior to construction and/or avoid clearing operations during the breeding season (DOE, 1995g).

Activities associated with operation, such as noise, increased human presence and traffic, and night lighting could affect wildlife living immediately adjacent to the storage site. While these disturbances could cause some sensitive species to move from the area, most animals should be able to adjust (DOE, 1995g).

Wetlands: Construction of a new dry storage facility would likely displace the forested wetlands adjacent to tributaries of Grassy Creek flowing through the potential site. This unavoidable displacement of wetlands would be accomplished in accordance with U.S. Army Corps of Engineers and Tennessee Water Quality Control Administration requirements. The potential also exists to disturb wetlands further downstream through erosion and sedimentation. Such impacts would be controlled through implementation of a soil erosion and sediment control plan. Construction-related discharges to Grassy

Creek would be relatively low and have negligible impacts to wetlands associated with the creek. No impacts to wetlands are anticipated during facility operations (DOE, 1995g).

Construction of a new dry storage facility would require the rechanneling of tributaries to Grassy Creek that cross the potential site, thus causing the loss of this aquatic habitat. In addition, soil erosion due to construction could cause water quality changes (primarily sediment loading) to Grassy Creek and its tributaries. These impacts could be minimized by implementation of soil erosion and sediment control measures. No operational impacts to aquatic resources are anticipated. It is assumed that the potential project would have a water retention pond within the security fence that might provide minimal habitat for amphibians in the area.

Threatened and Endangered Species: No Federally-listed species are expected to be affected. Site surveys would be required to verify the presence of State-listed or other special status species. Land clearing activities could destroy protected plant species, such as purple fringeless orchid and pink lady's-slippers, that may occur within the site. State-listed species including the Cooper's, sharp-shinned, and red-shouldered hawks, the barn owl, and the black vulture, which potentially occur in the area, could be impacted by project activities. Approximately 16 ha (40 acres) of potential nesting and foraging habitat would be lost as a result of construction activities. Because this type of habitat is abundant in the area, the loss would not be expected to affect the viability of populations of these species. However, appropriate steps would be taken to prevent nest disturbance. DOE would consult with the Tennessee Department of Environment and Conservation as appropriate to avoid or mitigate imminent impacts to State-listed species (DOE, 1995g). DOE would also consult with the U.S. Fish & Wildlife Service regarding threatened and endangered species for the proposed construction sites of foreign research reactor spent nuclear fuel storage facilities at the Oak Ridge Reservation. Impacts to threatened and endangered species are not anticipated.

F.4.4.2.1.9 Noise

Noises generated on the Oak Ridge Reservation do not propagate offsite at levels that impact the general population. Thus, the Oak Ridge Reservation noise impacts for both the Centralization and Regionalization by Fuel Type and Geography Alternatives would be those resulting from transportation of personnel and materials to and from the site that affect nearby communities, and those resulting from onsite sources that may affect some wildlife near these sources (DOE, 1995g).

The transportation noises are a function of the size of the work force (e.g., an increased work force would result in increased employee traffic and corresponding increases in deliveries by construction crews). Such noise and activity associated with construction would be expected to have short-term effects on most wildlife. Under the Centralization Alternative, the projected Oak Ridge Reservation work force would increase by about nine percent in the years 2000 to 2002 during peak construction, and decrease thereafter. There would be a corresponding increase in private vehicle and truck trips to the site. The day-night average sound level at 15 m (50 ft) from the roads that provide access to the Oak Ridge Reservation would be expected to increase by less than 1 decibel. No change is expected in the community reaction to noise along these routes. No mitigation of traffic noise impacts is proposed (DOE, 1995g).

F.4.4.2.1.10 Traffic and Transportation

Construction and operation of a new dry storage facility would involve a small increase in the number of employees commuting to the Oak Ridge Reservation and transportation of foreign research reactor spent nuclear fuel and hazardous chemicals within the site.

The maximum reasonably foreseeable scenario for construction and operation traffic occurs under the Centralization Alternative considered in the Programmatic SNF&INEL Final EIS. This would occur in 2001, when there would be about 4,200 full time employees and about 409,500 people in the region of influence. Construction and operation employees would contribute little to the future traffic because they represent such a small percentage of the region of influence population growth (DOE, 1995g). This conclusion would also be valid for a new dry storage facility for foreign research reactor spent nuclear fuel.

F.4.4.2.1.11 Occupational and Public Health and Safety

Emission-Related Impacts: Doses that could be received by the public during incident-free operation associated with the receipt and management of the foreign research reactor spent nuclear fuel at the Oak Ridge Reservation would be attributed to emissions of radioactive material that could be carried by the wind offsite. The general public would be too far from the locations where handling activities or storage take place to receive any dose from direct exposure. Doses were calculated for the MEI, defined as an individual at the site boundary receiving the maximum exposure, and for the general population within an 80 km (50 mi) radius of the storage facility. These doses would result from incident-free airborne radiological emissions assumed to be released from the unloading of the transportation cask and the storage facility during storage. The methodology and assumptions used for the calculation of the radiological emissions and resulting doses are discussed in Section F.6 of this appendix. Table F-71 summarizes the annual emission-related doses to the public and the associated risks for the MEI and population at the Oak Ridge Reservation. Integrated doses for the duration of a specific period can be obtained by multiplying the annual dose by the number of years in the period.

Table F-71 Annual Public Impacts for Foreign Research Reactor Spent Nuclear Fuel Receipt and Storage at the Oak Ridge Reservation (New Dry Storage)

Facility	*MEI Dose (mrem/yr)*	*MEI Risk (LCF/yr)*	*Population Dose (person rem/yr)*	*Population Risk (LCF/yr)*
Receipt/Unloading at: • New Dry Storage Facility	0.089	4.5×10^{-8}	0.085	0.000043
Storage at: • New Dry Storage Facility	0	0	0	0

Handling-Related Impacts: Workers at the site would receive radiation doses during handling operations (i.e., receiving and unloading the transportation cask). Analysis option 4A involves the receipt of 161 shipments of foreign research reactor spent nuclear fuel from the Idaho National Engineering Laboratory or the Savannah River Site and 193 shipments directly from ports into a dry storage facility. The assumptions and methodologies used to calculate the doses to a working crew associated with the handling activities of the foreign research reactor spent nuclear fuel are described in Section F.5 of this appendix.

Table F-72 presents the population dose and risk that would be received by the members of the working crew if that working crew handled the total number of transportation casks at the Oak Ridge Reservation.

The worker MEI doses and risks were not calculated because of the large uncertainties associated with the assumptions for such calculations. However, the upper bound for such a dose would be equal to the administrative or regulatory limit at the site. For DOE radiation workers, the regulatory limit is 5,000 mrem per year. All these workers would be monitored and if any worker's dose approached this limit, he or she would be rotated into a different job to prevent further exposure. This regulatory limit provides a very conservative upper bound on the radiation dose for the worker MEI. If a single worker received the full 5,000 mrem per year dose for the full 13 years of potential foreign research reactor spent nuclear fuel receipt, then the MEI dose would be 65,000 mrem. For this dose, the associated risk of incurring an LCF would be 2.6 percent.

Table F-72 Handling-Related Impacts to Workers at the Oak Ridge Reservation (New Dry Storage)

	Worker Population Dose (Person-rem)	*Worker Population Risk (LCF)*
	New Dry Storage	*New Dry Storage*
Phase 2	266/113[a]	0.11/0.05[a]

[a] *The two numbers represent the cask/vault designs respectively*

F.4.4.2.1.12 Material, Utility, and Energy Requirements

Construction of a new dry storage facility at the Oak Ridge Reservation would consume 21,800 m^3 (28,500 yd^3) of concrete and 5,200 metric tons (5,750 tons) of steel. The total energy and water requirements during construction are estimated to be 835,000 l (221,000 gal) for fuel, and 7.75 million l (2 million gal) for water. The annual utility and energy requirements during operations are shown in Table F-73. These requirements represent a small percent of current requirements for the Oak Ridge Reservation. No new generation or treatment facilities would be necessary, and connections to existing networks would require only short tie-in lines. Increases in consumption would be minimal because overall activity on the Oak Ridge Reservation is expected to decrease because of changes in site mission and a general reduction in employment.

Table F-73 Annual Utility and Energy Requirements for New Dry Storage at the Oak Ridge Reservation

Commodity	*Baseline Site Usage*	*Dry Storage Usage*	*Percent Increase*
Electricity (MW-hr/yr)	335,800	800 - 1,000	0.3 percent
Fuel (l/yr)	3,600[c]	0	0 percent
Water (l/yr)	3,060,000,000	1,590,000[a] 400,000[b]	0.05 percent[a] 0.01 percent[b]

[a] *During receipt and handling*

[b] *During storage*

[c] *Decatherms/yr of natural gas*

F.4.4.2.1.13 Waste Management

Construction of a new dry storage facility at the Oak Ridge Reservation would generate 1,800 m^3 (2,400 yd^3) of debris. The annual quantities of waste generated during operations are shown in

Table F-74. These quantities represent a very small percent increase above current levels at the Oak Ridge Reservation. Existing waste management storage and disposal activities at Oak Ridge Reservation could accommodate the waste generated by a new dry storage facility. Therefore, the impact of this waste on existing Oak Ridge Reservation waste management capacities would be minimal.

Table F-74 Annual Waste Generated for New Dry Storage at the Oak Ridge Reservation

Waste Form	*Baseline Site Generation*	*Dry Storage Generation*	*Percent Increase*
High-Level (m^3/yr)	0	0	0 percent
Transuranic (m^3/yr)	16	0	0 percent
Solid Low-Level (m^3/yr)	6,902	22[a] 1[b]	0.32 percent[a] 0.01 percent[b]
Wastewater (l/yr)	754,000,000	1,590,000[a] 400,000[b]	0.21 percent[a] 0.05 percent[b]

[a] *During receipt and handling*

[b] *During storage*

F.4.4.2.2 Wet Storage

Analysis option 4B involves long-term wet storage of foreign research reactor spent nuclear fuel at the Oak Ridge Reservation. This storage option would require the construction of a new wet storage facility.

F.4.4.2.2.1 Land Use

A new wet storage facility would be located in a 36-ha (90-acres) area in the eastern portion of West Bear Creek Valley. The majority of the land in this area can be characterized as vacant, unused, and ready for development. Use of West Bear Creek Valley for foreign research reactor spent nuclear fuel storage would be consistent with existing land use plans, which designate this area for general use. Construction activities, including laydown areas, would disturb 16 ha (40 acres) of land. This represents about 44 percent of the space designated for foreign research reactor spent nuclear fuel storage; however, this represents only about 0.1 percent of the entire Oak Ridge Reservation. A new wet storage facility would occupy 3,800 m^2 (41,000 ft^2) of land and would move 18,000 m^3 (24,000 yd^3) of soil. Neither construction nor operation of a new wet storage facility at any of the areas would significantly impact land use patterns on Oak Ridge Reservation.

F.4.4.2.2.2 Socioeconomics

As discussed in Section F.3.2 the total capital cost of a new wet storage facility is estimated to be $449 million. Construction activities are projected to take 4 years. Assuming that the capital cost is evenly distributed over this 4-year period, the annual expenditures would be about $112.2 million. This represents approximately 8.2 percent of the estimated FY 1995 total expenditures for the Oak Ridge Reservation (1,174 million). The relative socioeconomic impact from annual construction expenditures on the region of influence would be positive. The annual operations costs of a new wet storage facility are estimated to be $23.3 million for receipt and handling and $3.5 million for storage. These costs represent about 2 percent and 0.3 percent of FY 1995 total expenditures for the Oak Ridge Reservation. The relative socioeconomic impact from annual operation expenditures on the region of influence would be small.

Direct employment associated with construction of a new wet storage facility is estimated to be 157 persons. The relative socioeconomic impact from direct construction employment on the region of influence would be small. In addition, when compared to the projected FY 1995 work force at the Oak Ridge Reservation of approximately 17,000 persons, the relative socioeconomic impact of this temporary increase in construction employment would be insignificant. Direct employment associated with operations of a new wet storage facility is estimated to be 30 persons. The relative socioeconomic impact of this increase in operations employment would be insignificant to both the region of influence and the Oak Ridge Reservation.

F.4.4.2.2.3 Cultural Resources

Impacts to cultural resources would be the same as for new dry storage (Section F.4.4.2.1.3).

F.4.4.2.2.4 Aesthetic and Scenic Resources

Impacts to aesthetic and scenic resources would be the same as for new dry storage (Section F.4.4.2.1.4).

F.4.4.2.2.5 Geology

Impacts to geology would be the same as for new dry storage (Section F.4.4.2.1.5).

F.4.4.2.2.6 Air Quality

Nonradiological Emissions: Construction of a new wet storage facility would necessitate the clearing and grading of approximately 3 ha (7 acres) of land. In comparison, approximately 4 ha (10 acres) of land would be disturbed by new dry storage construction. Therefore, air quality impacts associated with wet storage construction would be bound by those associated with dry storage construction (Section F.4.4.2.1.6).

No nonradiological emissions from the operation of the new wet storage facility are expected.

Radiological Emissions: Incident-free airborne releases from the new wet storage facility would be limited to radioactive noble gases and some radioactive iodine which could be released from the stored fuel prior to canning. The airborne materials released to the building atmosphere during incident-free operations would be filtered by the building heating and ventilation system. Radioactive and nonradioactive effluent gases would be routed through double banked high efficiency particulate air filters prior to release to the environment through an exhaust air system. The high efficiency particulate air filters would have a minimum efficiency of 99.97 percent for 0.3 micron diameter particulates and would allow in-place dioctyl phthalate testing.

The new wet storage facility would discharge all ventilated gas, except truck exhaust, to the facility's exhaust system. Truck exhaust would be discharged directly to the environment during cask off-loading operations in the truck receiving area. The exhaust air system would employ a detector to monitor ^{137}Cs. For other building areas which would be sources of airborne radioactive contamination, the heating, ventilating, and air conditioning system would be designed to maintain airflow from areas of low potential contamination into areas of higher potential contamination. These airborne effluents would be required to be below the radioactivity concentration guides listed in DOE Order 5480.1B for both onsite and offsite concentrations (DOE, 1989b). Air emissions from the wet storage facility are expected to be similar to the air emissions from the CPP-603 at the Idaho National Engineering Laboratory. The annual air emission for the CPP-603 was designed to result in ground-level concentrations of less than 0.003 percent of DOE 5480.1B limits for uncontrolled areas. Radiological emissions from the operation of the wet storage facility were calculated based on the methodology and assumptions used in Section F.6.

F.4.4.2.2.7 Water Resources

The annual water usage during construction and operations of a new wet storage facility is estimated to be about 1.9 million l (502,000 gal) and 2.7 million l (720,000 gal), respectively. With an annual average water usage of approximately 3,060 million l (808 million gal) for the Oak Ridge Reservation, these amounts represent an increase of about 0.06 percent and 0.09 percent, respectively. Therefore, a new wet storage facility would have minimal impact on water resources at the Oak Ridge Reservation.

Best-management practices during construction would prevent sediment runoff or spills of fuels or chemicals. Therefore, construction activities should have no impact on water quality at the Oak Ridge Reservation. The impact on water quality during operations would also be negligible. Existing water treatment facilities at the Oak Ridge Reservation could accommodate any new domestic and process wastewater streams from a new wet storage facility. The expected total flow volumes at the Oak Ridge Reservation would still be well within the design capacities of treatment systems at the Oak Ridge Reservation. A new wet storage facility would meet National Pollutant Discharge Elimination System limits and reporting requirements, so no impact on the water quality of receiving streams is expected.

F.4.4.2.2.8 Ecology

Impacts to ecology would be the same as for new dry storage (Section F.4.4.2.1.8).

F.4.4.2.2.9 Noise

Impacts from noise would be the same as for new dry storage (Section F.4.4.2.1.9).

F.4.4.2.2.10 Traffic and Transportation

Impacts from traffic and transportation would be the same as for new dry storage (Section F.4.4.2.1.10).

F.4.4.2.2.11 Occupational and Public Health and Safety

Emission-Related Impacts: Doses that could be received by the public during incident-free operation associated with the receipt and management of the foreign research reactor spent nuclear fuel at the Oak Ridge Reservation would be attributed to emissions of radioactive material that could be carried by wind offsite. The public would be too far from the locations where handling activities or storage take place to receive any dose from direct exposure. Doses were calculated for the MEI, defined as an individual at the site boundary receiving the maximum exposure, and for the general population within an 80 km (50 mi) radius of the storage facility. These doses would result from routine airborne radiological emissions assumed to be released from the unloading of the transportation cask and the storage facility during storage. The methodology and assumptions used for the calculation of the radiological emissions and resulting doses are discussed in Section F.5 of this appendix. Table F-75 summarizes the annual emission-related doses to the public and the associated risks for the MEI and population at the Oak Ridge Reservation. Integrated doses for the duration of a specific implementation period can be obtained by multiplying the annual dose by the number of years in the period.

Table F-75 Annual Public Impacts for Foreign Research Reactor Spent Nuclear Fuel Receipt and Storage at Oak Ridge Reservation (Implementation Alternative 5 of Management Alternative 1)

Facility	*MEI DOSE (mrem/yr)*	*MEI Risk (LCF/yr)*	*Population Dose (person-rem/yr)*	*Population Risk (LCF/yr)*
Receipt/Unloading at: • New Wet Storage Facility	0.060	3.0×10^{-8}	0.061	0.000031
Storage at: • New Wet Storage Facility	4.6×10^{-7}	2.3×10^{-13}	5.0×10^{-7}	2.5×10^{-10}

Handling-Related Impacts: Workers at the site would receive radiation doses during handling operations (i.e., receiving and unloading the transportation cask), transferring the foreign research reactor spent nuclear fuel from one facility to another, or preparing the foreign research reactor spent nuclear fuel for shipment offsite. Analysis option 4B involves the receipt of 161 shipments of foreign research reactor spent nuclear fuel from the Idaho National Engineering Laboratory and/or the Savannah River Site, and 193 shipments directly from ports into a wet storage facility. The assumptions and methodologies used to calculate the doses to a working crew associated with the handling activities of the foreign research reactor spent nuclear fuel are described in Section F.5 of this appendix.

Table F-76 presents the population dose and risk that would be received by the members of the working crew if that working crew handled the total number of transportation casks at the Oak Ridge Reservation. The worker MEI doses and risks were not calculated because of the large uncertainties associated with the assumptions for such calculations. However, the upper bound for such a dose would be equal to the administrative limits at the site. For DOE radiation workers, the regulatory limit is 5,000 mrem per year. All these workers would be monitored and if any worker's dose approached this limit, he or she would be rotated into a different job to prevent further exposure. This regulatory limit provides a very conservative upper bound on the radiation dose for the worker MEI. If a single worker received the full 5,000 mrem per year dose for the full 13 years of potential foreign research reactor spent nuclear fuel receipt, then the MEI dose would be 65,000 mrem. For this dose, the associated risk of incurring an LCF would be 2.6 percent.

Table F-76 Handling-Related Impacts to Workers at the Oak Ridge Reservation (Implementation Alternative 5 of Management Alternative 1)

	Worker Population Dose (Person-rem)	*Worker Population Risk (LCF)*
	New Wet Storage	*New Wet Storage*
Phase 2	109	0.04

F.4.4.2.2.12 Material, Utility, and Energy Requirements

Construction of a new wet storage facility at Oak Ridge Reservation would consume 12,400 m^3 | (16,260 yd^3) of concrete and 3,100 metric tons (3,443 tons) of steel. The total energy and water requirements during construction are estimated to be 600,000 l (159,000 gal) for fuel, and 4.4 million l | (1.2 million gal) for water. The annual utility and energy requirements during operations are shown in

Table F-77. These requirements represent a small percent of current requirements for the Oak Ridge Reservation. No new generation or treatment facilities would be necessary, and connections to existing networks would require only short tie-in lines. Increases in consumption would be minimal because overall activity on the Oak Ridge Reservation is expected to decrease because of changes in site mission and a general reduction in employment.

Table F-77 Annual Utility and Energy Requirements for Wet Storage at the Oak Ridge Reservation (Implementation Alternative 5 of Management Alternative 1)

Commodity	Baseline Site Usage	Wet Storage Usage	Percent Increase
Electricity (MW-hr/yr)	335,800	800 - 1,000	0.15 percent
Fuel (l/yr)	3,600[a]	0	0 percent
Water (l/yr)	3,060,000,000	2,700,000[b] 1,500,000[c]	0.09 percent 0.05 percent

[a] *Decatherms/yr of natural gas*

[b] *During receipt and handling*

[c] *During storage*

F.4.4.2.2.13 Waste Management

Construction of a new wet storage facility at the Oak Ridge Reservation would generate 2,600 m^3 (10,300 yd^3) of debris. The annual quantities of waste generated during operations are shown in Table F-78. These quantities represent a very small percentage increase above current levels at the Oak Ridge Reservation. Existing waste management storage and disposal activities at the Oak Ridge Reservation could accommodate the waste generated by a new wet storage facility. Therefore, the impact of this waste on existing the Oak Ridge Reservation waste management capacities would be minimal.

Table F-78 Annual Waste Generated for Wet Storage at the Oak Ridge Reservation (Implementation Alternative 5 of Management Alternative 1)

Waste Form	Baseline Site Generation	Wet Storage Generation	Percent Increase
High-Level (m^3/yr)	0	0	0 percent
Transuranic (m^3/yr)	16	0	0 percent
Solid Low-Level (m^3/yr)	6,902	16[a] 1[b]	0.23 percent 0.01 percent
Wastewater (l/yr)	754,000,000	1,590,000[a] 400,000[b]	0.21 percent 0.05 percent

[a] *During receipt and handling*

[b] *During storage*

F.4.4.3 Accident Analysis

An evaluation of incident-free operations and hypothetical accidents at the Oak Ridge Reservation is presented here based on the methodology in Appendix F, Section F.6. The evaluation assessed the possible radiation exposure to individuals and general population due to the release of radioactive materials. The analyses are based on the same operations carried out at the different potential storage locations and the same accidents at any of the sites evaluated. Information concerning radiation doses to individuals and the general population are the same as set forth in Section F.4.1.3.

Table F-79 presents the frequencies and the consequences in terms of mrem or person-rem, of postulated accidents to the offsite MEI, NPAI, and offsite population for the 95th-percentile meteorological conditions using the assumptions and input values discussed above. The worker doses are calculated only for the 50th-percentile meteorology. This is an individual assumed to be 100 m (330 ft) downwind of the accident. DOE did not estimate the worker population dose.

Table F-79 Frequency and Consequences of Accidents at the Oak Ridge Reservation

	Frequency (per year)	*Consequences*			
		MEI (mrem)	*NPAI (mrem)*	*Population (person-rem)*	*Worker (mrem)*
Dry Storage Accidents[a]					
• Spent Nuclear Fuel Assembly Breach	0.16	22	42	55	140
• Dropped Spent Nuclear Fuel Cask	0.0001	1.4	0.18	15	0.61
• Aircraft Crash w\Fire	0.000001	2300	180	2900	610

[a] *New Dry Storage Facility*

Multiplying the frequency of each accident times its consequences and converting the radiation doses to LCF yields the annual risks associated with each potential accident at the Oak Ridge Reservation. These annual risks are multiplied by the maximum duration of this implementation alternative at each site to obtain conservative estimates of risks for the Oak Ridge Reservation. These risk estimates are presented in Table F-80.

Table F-80 Annual Risks of Accidents at the Oak Ridge Reservation

	Risks			
	MEI (LCF/yr)	*NPAI (LCF/yr)*	*Population (LCF/yr)*	*Worker (LCF/yr)*
Dry Storage Accidents[a]				
• Spent Nuclear Fuel Assembly Breach	0.0000018	0.0000034	0.0044	0.0000088
• Dropped Spent Nuclear Fuel Cask	7.0×10^{-11}	9.0×10^{-12}	7.5×10^{-7}	2.4×10^{-11}
• Aircraft Crash w/Fire	1.2×10^{-9}	9.0×10^{-11}	0.0000015	2.4×10^{-10}

[a] *New Dry Storage Facility*

Table F-81 presents the frequency and consequences of the accidents analyzed for each site for wet storage (Implementation Alternative 5 of Management Alternative 1). Multiplying the frequency of each accident times its consequences at each site and converting the radiation doses to LCF yields the annual risks associated with each potential accident at the Oak Ridge Reservation. These annual risks are multiplied by the maximum duration of this implementation alternative at each site to obtain conservative estimates of risks at the Oak Ridge Reservation. Table F-82 presents the risk estimates from this implementation alternative.

F.4.4.3.1 Secondary Impact of Radiological Accidents at the Oak Ridge Reservation

In the event of an accidental release of radioactivity, there is a potential for impacts to land uses, cultural resources, water quality, ecology, national defense, and local economies (secondary impacts). For this analysis, secondary impacts of radiological accidents involving foreign research reactor spent nuclear fuel have been qualitatively assessed based on the calculations presented in Section F.4.4.3. Radiological

Table F-81 Frequency and Consequences of Accidents at the Oak Ridge Reservation (Implementation Alternative 5 of Management Alternative 1)

	Frequency (per year)	Consequences			
		MEI (mrem)	NPAI (mrem)	Population (person-rem)	Worker (mrem)
New Wet Storage Facility					
• Spent Nuclear Fuel Assembly Breach	0.16	0.71	0.20	16	0.68
• Accidental Criticality	0.0031	1,500	3,300	1,400	6,800
• Aircraft Crash	0.000001	380	600	2,900	1,900

Table F-82 Annual Risks of Accidents at the Oak Ridge Reservation (Implementation Alternative 5 of Management Alternative 1)

	Risks			
	MEI (LCF/yr)	NPAI (LCF/yr)	Population (LCF/yr)	Worker (LCF/yr)
New Wet Storage Facility				
• Spent Nuclear Fuel Assembly Breach	5.5×10^{-8}	1.6×10^{-8}	0.0013	4.4×10^{-8}
• Accidental Criticality	0.0000024	0.000005	0.0022	0.0000084
• Aircraft Crash	1.9×10^{-10}	3.0×10^{-10}	0.0000015	7.6×10^{-10}

accidents that resulted in doses to the MEI of less than the annual Federal radiological exposure limit for the public of 100 mrem (10 CFR Part 20) were considered to have no secondary impacts.

The MEI dose provides a measure of the air concentration and radionuclide deposition at the receptor location. As such, it can be used to express the level of contamination from a given radiological accident. In estimating the human health effects from radiological exposure (as presented in Section F.4.1.3), the MEI dose evaluates four pathways: (1) air immersion, (2) ground surface, (3) inhalation, and (4) ingestion. In estimating the environmental effects from radiological exposure, however, only the air immersion and ground surface pathways need be considered.

At the Oak Ridge Reservation, the radiological accident with the highest MEI dose is the aircraft crash into a dry storage facility with fire. For this accident, the MEI dose would be 2,300 mrem. For the air immersion and ground surface pathways only, the dose would be 140 mrem, which is greater than the 100 mrem limit used in this analysis. Local contamination would be likely around the dry storage facility, but is expected to be contained entirely within the boundaries of the Oak Ridge Reservation. Cleanup activities should be small and any impacts to land uses, cultural resources, water quality, and ecology would be reversible. No impacts to national defense or local economies would be expected.

F.4.4.4 Cumulative Impacts at the Oak Ridge Reservation

This section presents the cumulative impacts of the proposed action, potential impacts of other contemplated major DOE actions, and current activities at the site. A major portion of the presentation is based on information included in the Programmatic SNF&INEL Final EIS (DOE, 1995g), the Tritium Supply and Recycling Final EIS (DOE, 1995a), and the Disposition of Surplus Highly Enriched Uranium Draft EIS (DOE, 1995e). Other activities considered for the Oak Ridge Reservation which could affect the site environment have not been determined sufficiently at this time to allow impact evaluation. They include activities associated with the waste management at the site, storage and disposition of weapons-usable fissile materials, and stockpile stewardship and management program.

Tables F-83 and F-83A summarize the cumulative impacts for land use, socioeconomics, air quality, occupational and public health and safety, energy and water consumption, and waste generation at the site. Table F-83 also presents the contribution from the storage of foreign research reactor spent nuclear fuel on the cumulative impacts at the Oak Ridge Reservation. For the purposes of this analysis, both the contributions from management of foreign research reactor spent nuclear fuel and the cumulative impacts were maximized by selecting the Centralization Alternative of the Programmatic SNF&INEL Final EIS at the Oak Ridge Reservation.

As shown in Table F-83, the contribution from storage of foreign research reactor spent nuclear fuel to the cumulative impacts (under the Centralization Alternative) at the Oak Ridge Reservation would be minimal. The Programmatic SNF&INEL Final EIS concludes that the implementation of any of the alternatives (including the Centralization Alternative) for the DOE spent nuclear fuel management program would not be expected to significantly contribute to cumulative impacts (DOE, 1995g). This conclusion is also valid for the implementation of any of the alternatives considered in this EIS for storage of foreign research reactor spent nuclear fuel at the Oak Ridge Reservation.

F.4.4.5 Unavoidable Adverse Environmental Impacts

Construction of the potential foreign research reactor spent nuclear fuel storage facilities would require the disturbance of approximately 16 ha (40 acres) of mostly forested undeveloped land. Although this represents less than one percent of the undeveloped land on the Oak Ridge Reservation, it would eliminate potential foraging and nesting habitat and would destroy plant species in the area. It would also require the dedication of a reasonably level land parcel that could otherwise accommodate other construction projects.

F.4.4.6 Irreversible and Irretrievable Commitments of Resources

Construction and operation of new foreign research reactor spent nuclear fuel storage facilities would require commitments of electrical energy, fuel, concrete, steel, sand, gravel and miscellaneous chemicals. Most of the water that would be withdrawn from the Clinch River to operate the foreign research reactor spent nuclear fuel facilities would be returned to surface water in the Clinch River watershed, although some evaporative losses would be unavoidable. The land dedicated to the foreign research reactor spent nuclear fuel facilities could become available for other urban uses following closure and decommissioning. However, the soils on the site would have to be amended to support land uses such as agriculture, forestry, or wildlife management.

F.4.4.7 Mitigation Measures

Mitigation is addressed in general terms and describes typical measures that the Oak Ridge Reservation could implement. The analyses indicate that the environmental consequences attributable to foreign research reactor spent nuclear fuel management activities at the Oak Ridge Reservation would be minimal in most environmental media.

Pollution Prevention: The DOE Oak Ridge Field Office established a Waste Minimization and Pollution Prevention Awareness Plan to reduce the quantity and toxicity of hazardous, mixed, and radioactive wastes generated at the Oak Ridge Reservation. The plan is designed to reduce the possible pollutant releases to the environment and thus increase the protection of employees and the public. All contractors and users that exceed the U.S. Environmental Protection Agency criteria for small-quantity generators are

Table F-83 Cumulative Impacts at the Oak Ridge Reservation

Environmental Impact Parameter	*FRR SNF Contribution*	*Other Activities*[a]	*Cumulative Impact*
Land Use (acres)	40	14,335[b]	14,375
Socioeconomics (persons)	190[b]/30[c]	3,917[b]/930[c]	4,107[b]/960[c]
Air Quality (nonradiological)	See Table F-83A	See Table F-83A	See Table F-83A
Occupational and Public Health and Safety			
• MEI Dose (rem/yr)	0.00009	0.0155	0.0156
LCF (per year)	$4.5x10^{-8}$	0.0000077	0.0000078
• Population Dose (person-rem/yr)	0.085	94.5	94.6
LCF (per year)	0.000043	0.047	0.047
• Worker Collective Dose (person-rem/yr)	8.9[d]	261.3	270.2
LCF (per year)	0.0036	0.104	0.108
Energy and Water Consumption			
• Electricity (MW-hr/yr)	1,000	4,981,000[e]	4,982,000
• Natural Gas (million m^3/yr)	0	68.64	68.64
• Coal (tons/yr)	0	35,053	35,053
• Diesel Oil (million l/yr)	0	4.83	4.83
• Water (million l/yr)	2.2	68,172	68,174
Waste Generation			
• High-Level (m^3/yr)	0	0	0
• Low-Level (m^3/yr)	22	34,989	35,011
• Transuranic (m^3/yr)	0	16	16
• Mixed/Hazardous (m^3/yr)	0	119,411	119,411

[a] *Other activities include: DOE-owned spent nuclear fuel management, construction and operation of the Expended Core Facility, the construction and operation of the Advanced Neutron Source Facility, construction and operation of a Tritium production facility, and surplus highly enriched uranium management activities at the site*

[b] *Increase over baseline (17,000), during construction activities*

[c] *Increase over baseline (17,000), during operation activities*

[d] *The dose is due to the handling of Foreign Research Reactor Spent Nuclear Fuel during receipt averaged over 30 years*

[e] *Major portion of the requirement for electricity by the proposed tritium production facility (3,740,000 MW-hr/yr)*

establishing their own waste minimization and pollution prevention awareness programs. Contractor programs ensure that waste minimization activities are in accordance with Federal, State, and local environmental laws and regulations, and DOE orders (DOE, 1995g).

Additional goals include the promotion and use of nonhazardous materials, establishment of a baseline of waste generation data, calculations of annual reductions of waste generated, and implementation of recycling programs. Goals also include incorporation of waste minimization concepts and technologies in planning and design of new processes and facilities, and in upgrades of existing facilities. A waste minimization task force composed of representatives from each contractor has been established to coordinate waste minimization and pollution awareness activities (DOE, 1995g).

Socioeconomics: To reduce construction- and operation-related impacts, coordination with local communities could address potential impacts from increased labor and capital requirements. The knowledge of the extent and effect of growth due to foreign research reactor spent nuclear fuel

Table F-83A Estimated Maximum Nonradiological Cumulative Ground-Level Concentrations of Criteria and Toxic Pollutants at the Oak Ridge Reservation[a]

Pollutant	Averaging Time	Regulatory Standard ($\mu g/m^3$)	Cumulative Concentration[b] ($\mu g/m^3$)
Carbon Monoxide	1-hour	40,000	3,696 (9.2%)
	8-hour	10,000	2,495 (24.9%)
Nitrogen Oxides	Annual	100	13 (13%)
Surfur Dioxide	3-hour	1,300	336.6 (25.9%)
	24-hour	365	5.84 (1.6%)
	Annual	80	3.62 (4.52%)
Particulate Matter (PM_{10})	24-hour	150	88.1 (58.7%)
	Annual	50	0.48 (0.96%)
Total Suspended Particulates	Annual	150	119 (79.3%)

[a] *Concentrations represent activities from: foreign research reactor spent nuclear fuel management, DOE-owned spent fuel management, construction and operation of the Expended Core Facility, construction and operation of the Advanced Neutron Source Facility, construction and operation of a tritium supply and recycling facility, and surplus highly enriched uranium management at the site*

[b] *Numbers in parentheses indicate the percentage of the regulatory standard*

management activities could greatly enhance the ability of affected jurisdictions to plan effectively. Effective planning would address change in levels of service for housing, infrastructure, utilities, transportation, and public services and finances (DOE, 1995g).

To alleviate potential impacts associated with the in-migration of labor, local labor force availability could be increased through various employment training and referral systems currently provided by the Oak Ridge Reservation. The goal of these systems would be to reduce the potential for in-migration of labor to support foreign research reactor spent nuclear fuel management activities (DOE, 1995g).

Water Resources: The potential foreign research reactor spent nuclear fuel storage facilities would have to be located and constructed to minimize floodplain impacts and to avoid floodplains to the maximum extent possible, as required by Executive Order 11988 (Floodplain Management) and DOE rule 10 CFR 1022. Site-specific surveys would be performed to determine locations of flooding elevations more accurately (DOE, 1995g).

Ecology: DOE would consult with the Tennessee Department of Environment and Conservation as appropriate to avoid or mitigate imminent impacts to State-listed species (DOE, 1995g).

Accidents: New foreign research reactor spent nuclear fuel storage facilities would be designed to comply with current Federal, State, and local laws, DOE orders, and industrial codes and standards. This would provide facilities that are highly resistant to the effects of severe natural phenomena, including earthquakes, floods, tornadoes, high winds, as well as credible events as appropriate to the site, such as fires and explosions, and manmade threats to its continuing structural integrity for containing materials (DOE, 1995g).

Emergency preparedness plans have also been prepared for existing facilities and would be revised for new facilities to lower the potential consequences of an accident to workers and the public. All workers receive evacuation training to ensure timely and orderly personnel movement away from high-risk areas. Plans and arrangements with local authorities would also be in place to evacuate the general public that may be at risk of exposure to hazardous materials that are accidentally released (DOE, 1995g).

F.4.5 Nevada Test Site

If the Nevada Test Site is the site to manage DOE-owned spent nuclear fuel under the Programmatic SNF&INEL Final EIS, foreign research reactor spent nuclear fuel would be received and managed first at the Savannah River Site and/or the Idaho National Engineering Laboratory for the period required for the Nevada Test Site to construct and to place in operation new facilities to accommodate the spent nuclear fuel. As discussed in previous sections, this period (Phase 1) is estimated to be about 10 years. At the end of Phase 1 (e.g., start of Phase 2), the Nevada Test Site would be able to receive and manage foreign research reactor spent nuclear fuel that would be shipped from the Savannah River Site and/or the Idaho National Engineering Laboratory, and directly from the ports for those shipments made after Phase 1 concludes. Management of the foreign research reactor spent nuclear fuel would continue at the Nevada Test Site until ultimate disposition.

Although the Nevada Test Site has no existing facilities to receive foreign research reactor spent nuclear fuel at the beginning of the policy period, it has facilities that could be modified to receive foreign research reactor spent nuclear fuel within 5 years. These facilities are large hot cells located in the Nevada Research and Development Area on Jackass Flats. Presently these facilities (e.g., E-MAD) have little usage, but some are in acceptable condition. To use the E-MAD facility, a small pool would have to be constructed to be used for transferring the spent nuclear fuel from the transportation casks to containers designed for dry storage. A description of the E-MAD facility is included in Appendix F (Section F.3). The E-MAD facility could be ready within 5 years of the start of the proposed policy period.

The amount of spent nuclear fuel that would be received and managed at the Nevada Test Site under Management Alternative 1, is dictated by the distribution considered in the Programmatic SNF&INEL Final EIS. Accordingly, during Phase 2, the Nevada Test Site could receive the TRIGA spent nuclear fuel managed at the Idaho National Engineering Laboratory during Phase 1, Western foreign research reactor spent nuclear fuel under the Regionalization by Geography Alternative, or all foreign research reactor spent nuclear fuel under the Centralization Alternative.

As a Phase 2 site, the Nevada Test Site would receive and manage foreign research reactor spent nuclear fuel at a newly constructed dry storage facility or a modified E-MAD facility. Description of the new dry storage facility is provided in Section 2.6.5.1.1.

The analysis of potential environmental impacts from management of foreign research reactor spent nuclear fuel at the Nevada Test Site is based on the above considerations. The analysis options selected do not represent all possible combinations, but a reasonable set that provides a typical, and in some cases, bounding estimate of the resulting impacts.

The specific analysis options are as follows:

5A. The spent nuclear fuel managed at the Idaho National Engineering Laboratory and/or the Savannah River Site during Phase 1 would be shipped to the Nevada Test Site, where it would be managed at a new dry storage facility or a modified E-MAD facility. Spent nuclear fuel arriving in the United States after Phase 1 concludes would also be received and managed at the new or E-MAD facility until ultimate disposition. For the purposes of this analysis, the total amount of spent nuclear fuel that would be managed would be all the foreign research reactor spent nuclear fuel eligible under the policy (approximately 22,700 elements).

The implementation alternatives of Management Alternative 1 for managing foreign research reactor spent nuclear fuel in the United States, discussed in Section 2.2.2, introduce additional analysis options that could be considered for the Nevada Test Site as follows:

- Under Implementation Subalternative 1a (Section 2.2.2.1), the amount of spent nuclear fuel to be received in the United States would be reduced to 5,000 elements. In this case, the Nevada Test Site would receive the foreign research reactor spent nuclear fuel from the Idaho National Engineering Laboratory or the Savannah River Site and manage it in facilities sized for the reduced amount of spent nuclear fuel. The impacts from the management of this amount of spent nuclear fuel would be bounded by analysis option 5A above.

- Under Implementation Subalternative 1b (Section 2.3.1), the Nevada Test Site would receive from the Idaho National Engineering Laboratory and/or the Savannah River Site only HEU. The amount of HEU would be approximately 4.6 MTHM, representing 11,200 elements. The impacts from the storage of this amount of fuel would be bounded by analysis option 5A (above).

- Under Implementation Subalternative 1c (Section 2.2.2.1), the Nevada Test Site would receive target material in addition to the foreign research reactor spent nuclear fuel considered under the basic implementation of Management Alternative 1. The receipt and management of this material, which represents in uranium content approximately 620 typical foreign research reactor spent nuclear fuel elements, would increase the impacts of analysis option 5A by a small percentage.

- Under Implementation Subalternative 2a (Section 2.2.2.2), the duration of the policy would be decreased to 5 years and, therefore, the amount of spent nuclear fuel available for acceptance would also be decreased. In such a case, the Nevada Test Site would receive all foreign research reactor spent nuclear fuel from the Savannah River Site and/or the Idaho National Engineering Laboratory. The impacts from the management of the decreased amount of spent nuclear fuel at the Nevada Test Site would be bounded by analysis option 5A above.

- Under Implementation Subalternative 2b (Section 2.2.2.2) the acceptance of a small portion of the spent nuclear fuel would be extended over an indefinite period of time, but the amount of spent nuclear fuel to be received and managed would remain constant. The impacts would be the same as in analysis option 5A.

- Under Implementation Subalternative 3, (Section 2.2.2.3), DOE and the Department of State would consider alternative financial arrangements. The various arrangements would affect the amount of spent nuclear fuel that would be accepted by the United States as the foreign research reactor operators would consider their own alternatives on whether to send the spent nuclear fuel to the United States. The amount of spent fuel, in this case, cannot be quantified; however, the upper limit, as considered under analysis option 5A, would be bounding.

- Under Implementation Alternative 4 (Section 2.2.2.4), DOE and the Department of State would consider alternatives for the location where title of foreign research reactor spent nuclear fuel would be taken. The choices do not affect the management impacts at the Nevada Test Site.

- Under Implementation Alternative 5 (Section 2.2.2.5), DOE would consider construction of a new wet storage facility at the Nevada Test Site for Phase 2 until ultimate disposition. For this implementation alternative an analysis option 5B, which is similar to 5A, is considered as follows:

5B. The spent nuclear fuel managed at the Idaho National Engineering Laboratory and/or the Savannah River Site during Phase 1 would be shipped to the Nevada Test Site where it would be managed at a new wet storage facility. Spent nuclear fuel arriving in the United States after Phase 1 concludes would also be received and managed at the new facility until ultimate disposition. For the purposes of analysis, the total amount of spent nuclear fuel that would be managed in the wet storage facility would be all the foreign research reactor spent nuclear fuel eligible under the policy (approximately 22,700 elements). If the Nevada Test Site receives TRIGA spent nuclear fuel from the Idaho National Engineering Laboratory or only western spent fuel, the wet storage facility would be sized accordingly. The impacts from a smaller size facility would be bounded by the option analyzed.

- Under Implementation Alternative 6 (Section 2.3.6), DOE and the Department of State would consider chemical separation of foreign research reactor spent nuclear fuel in the United States. Based on the discussion in Section 2.3.6, the Nevada Test Site would not be considered as a site for chemical separation.

Under Management Alternative 3 (Hybrid Alternative) the Nevada Test Site is not considered.

F.4.5.1 Existing Facilities

Existing facilities considered for foreign research reactor spent nuclear fuel storage at the Nevada Test Site include the E-MAD facility in Area 25. For this analysis, the E-MAD facility was considered essentially as new because of the significant modifications needed to use it for foreign research reactor spent nuclear fuel storage. These modifications could be completed sometime between 1996 and 2006. The potential environmental impacts associated with the modification would be bounded by the impacts associated with the construction of a dry storage facility presented in Section F.4.5.2. Impacts from the operation of the E-MAD facility are presented below.

F.4.5.1.1 Socioeconomics

Potential socioeconomic impacts associated with storage option 5A would be attributable to staffing requirements at the E-MAD facility. The staffing requirements for dry storage would be about 120 full time employees. Considering that the total work force at the Nevada Test Site is approximately 4,000 (DOE, 1995g), the addition of 120 full time employees for foreign research reactor spent nuclear fuel storage is not expected to have any measurable socioeconomic impact in the region of influence.

F.4.5.1.2 Occupational and Public Health and Safety

Emission-Related Impacts: Doses that could be received by the public during incident-free operation associated with the receipt and management of the foreign research reactor spent nuclear fuel at the Nevada Test Site would be attributed to emissions of radioactive material that could be carried by wind offsite. The public would be too far from the locations where handling activities or storage take place to receive any dose from direct exposure. Doses were calculated for the MEI, defined as an individual at the site boundary receiving the maximum exposure, and for the general population within an 80 km (50 mi) radius of the storage facility. These doses would result from incident-free airborne radiological emissions assumed to be released from the unloading of the transportation cask and the storage facility during storage. The methodology and assumptions used for the calculation of the radiological emissions and resulting doses are discussed in Section F.5 of this appendix. For the purpose of these calculations, the refurbished E-MAD facility is treated as a generic dry storage facility. The annual emission releases from the dry storage facility during receipt and unloading and storage are provided in Section F.6.6. Table F-84 summarizes the annual emission-related doses to the public and the associated risks for the MEI and population at the Nevada Test Site. Integrated doses for the duration of a specific implementation period can be obtained by multiplying the annual dose by the number of years in the period.

Table F-84 Annual Public Impacts for Foreign Research Reactor Spent Nuclear Fuel Receipt and Storage at the Nevada Test Site

Facility	*MEI Dose (mrem/yr)*	*MEI Risk (LCF/yr)*	*Population Dose (person-rem/yr)*	*Population Risk (LCF/yr)*
Receipt/Unloading at: • E-MAD (dry storage)	0.00076	3.8×10^{-10}	0.00093	4.7×10^{-7}
Storage at: • E-MAD (dry storage)	0	0	0	0

Handling-Related Impacts: Workers at the site would receive radiation doses during handling operations (i.e., receiving and unloading the transportation cask). Analysis option 5A involves the receipt of 161 shipments of foreign research reactor spent nuclear fuel from the Idaho National Engineering Laboratory or the Savannah River Site and 193 shipments directly from ports into a dry storage facility. The assumptions and methodologies used to calculate the doses to a working crew associated with the handling activities of the foreign research reactor spent nuclear fuel are described in Section F.5 of this appendix.

Table F-85 presents the population dose and risk that would be received by the members of the working crew if that working crew handled the total number of transportation casks at the Nevada Test Site. The worker MEI doses and risks were not calculated because of the large uncertainties associated with the assumptions for such calculations. However, the upper bound for such a dose would be equal to the administrative or regulatory limit at the site. For DOE radiation workers, the regulatory limit is 5,000 mrem per year. All these workers would be monitored and if any worker's dose approached this limit, he or she would be rotated into a different job to prevent further exposure. This regulatory limit provides a very conservative upper bound on the radiation dose for the worker MEI. If a single worker received the full 5,000 mrem per year dose for the full 13 years of potential foreign research reactor spent nuclear fuel receipt, then the MEI dose would be 65,000 mrem. For this dose, the associated risk of incurring an LCF would be 2.6 percent.

Table F-85 Handling-Related Impacts to Workers at the Nevada Test Site

	Worker Population Dose (person-rem)	*Worker Population Risk (LCF)*
	E-MAD	*E-MAD*
Phase 2	113	0.05

F.4.5.1.3 Material, Utility, and Energy Requirements

The material, utility, and energy requirements for the E-MAD facility are typical of those for dry storage. Table F-86 presents the estimated material, utility and energy consumption for dry storage.

Table F-86 Annual Utility and Energy Requirements for Dry Storage at the Nevada Test Site

Commodity	Baseline Site Usage	Dry Storage Usage	Percent Increase
Electricity (MW-hr/yr)	176,440	800 - 1,000	0.6 percent
Fuel (l/yr)	[a]	0	0 percent
Water (l/yr)	1,138,000,000	1,590,000[b] 400,000[c]	0.14 percent 0.04 percent

[a] *The majority of the energy used at the Nevada Test Site is provided by electricity. Current usage is not available*

[b] *During receipt and handling*

[c] *During storage*

These requirements represent a small percent of current requirements for the Nevada Test Site. No new generation or treatment facilities would be necessary, and connections to existing networks would require only short tie-in lines. Increases in consumption would be minimal because overall activity on the Nevada Test Site is expected to decrease because of changes in site mission and a general reduction in employment.

F.4.5.1.4 Waste Management

The contribution of waste associated with the operation of the E-MAD facility is typical of that for new dry storage (Section F.4.5.2.1.13).

F.4.5.1.5 Air Quality

The contribution of air emissions associated with the operation of the E-MAD facility is typical to that for new dry storage (Section F.4.5.2.1.5).

F.4.5.1.6 Water Resources

The effect of the operation of the E-MAD facility on the water usage is typical to that for new dry storage (Section F.4.5.2.1.7).

F.4.5.2 New Facilities (Phase 2)

Analysis options 5A and 5B involve the use of new facilities as discussed above. The environmental impacts analyzed relate to the construction and operation of these facilities. The impacts include: land use; socioeconomics; cultural resources; aesthetic and scenic resources; geology; air and water quality; ecology; noise; traffic and transportation; occupational and public health and safety; materials, utilities, and energy; and waste management.

F.4.5.2.1 Dry Storage

Analysis option 5A involves long-term dry storage of foreign research reactor spent nuclear fuel at the Nevada Test Site. This analysis option would require the construction of a new dry storage facility. The analysis option encompasses both the dry vault design and the dry cask design as described in Section 2.6.5 and earlier in this appendix. There are no environmental impact parameters that would discriminate between the two designs.

F.4.5.2.1.1 Land Use

A new dry storage facility would be located in Area 5 in the southeastern portion of the Nevada Test Site. The land in this area can be characterized as sparsely vegetated desert, ready for development. Use of Area 5 for foreign research reactor spent nuclear fuel storage would be consistent with existing land use plans, which designate this area for general use. Construction activities, including laydown areas, would disturb 3.7 ha (9 acres) of land. A new dry storage facility would occupy 5,000 m^2 (54,000 ft^2) of land and would move 11,000 m^3 (14,400 yd^3) of soil. Neither construction nor operation of a new dry storage facility at any of the areas would significantly impact land use patterns on the Nevada Test Site.

F.4.5.2.1.2 Socioeconomics

As discussed in Section F.3.1.1 the total capital cost of a new dry storage facility is estimated to be \$370 million. Construction activities are projected to take 4 years. Assuming that the capital cost is evenly distributed over this 4-year period, the annual expenditures would be about \$92.5 million. This represents approximately 66 percent of the estimated FY 1995 total expenditures for the Nevada Test Site (141 million). The relative socioeconomic impact from annual construction expenditures on the region of influence would be positive. The annual operations costs of a new dry storage facility are estimated to be \$15.6 million for receipt and handling and \$0.6 million for storage. These costs represent about 11 percent and 0.5 percent of FY 1995 total expenditures for the Nevada Test Site. The relative socioeconomic impact from annual operation expenditures on the region of influence would be small.

Direct employment associated with construction of a new dry storage facility is estimated to be 190 persons. The relative socioeconomic impact from direct construction employment on the region of influence would not be significant. In addition, when compared to the projected FY 1995 work force at the Nevada Test Site of approximately 4,000 persons, the relative socioeconomic impact of this temporary increase in construction employment would be insignificant. Direct employment associated with receipt and storage operations is estimated to be 30 persons. Upon completion of these activities, direct employment is expected to decrease to eight persons. The relative socioeconomic impact of this increase in operations employment would be insignificant to both the region of influence and the Nevada Test Site.

F.4.5.2.1.3 Cultural Resources

There are no known historical, archaeological, paleontological, or Native American traditional sites in or around the potential storage site. No impacts to cultural resources are expected from ground disturbance, noise, or air emissions during facility construction or operation of the new dry storage facility. Consultation with the Nevada State Historic Preservation Office prior to project implementation is required under Section 106 of the National Historic Preservation Act of 1966. The State Historic Preservation Office may recommend further studies of the proposed storage site to verify that no archaeological areas would be disturbed by construction activities (DOE, 1995g).

F.4.5.2.1.4 Aesthetic and Scenic Resources

Construction and operation of a new dry storage facility for foreign research reactor spent nuclear fuel would have less impact on aesthetic and scenic resources at the Nevada Test Site than the construction of facilities for spent nuclear fuel management under the Centralization Alternative considered in the Programmatic SNF&INEL Final EIS (DOE, 1995g).

The proposed spent nuclear fuel facilities under Centralization, when fully constructed and under operation, would consist of a series of industrial buildings set within a 36-ha (90-acre) site. The site would not be visible from areas outside the Nevada Test Site. The new dry storage facility for foreign research reactor spent nuclear fuel would be constructed and operated under similar conditions. Potential soil erosion and dust generation associated with construction-related activities would be controlled by the implementation of best-management practices. Any visibility impacts from fugitive dust generation by construction-related activities should be insignificant and short term. Facility operations associated with the dry storage of foreign research reactor spent nuclear fuel should not generate any atmospheric emissions which would reduce area visibility.

F.4.5.2.1.5 Geology

The new dry storage facility for foreign research reactor spent nuclear fuel would be situated on tertiary volcanic or sedimentary rocks near volcanic or intrusive centers where small to medium-size precious metal deposits could be developed. However, because the Nevada Test Site is closed to mining operations, any precious metal deposits that might exist in or around the potential storage site would not be impacted (DOE, 1995g). Further, no mass movement or subsidence and sediment runoff from land disturbances would be expected (DOE, 1995g). The operation of the new dry storage facility would have no effect on the geologic characteristics at the site.

F.4.5.2.1.6 Air Quality

Nonradiological Emissions: Potential air quality impacts at the Nevada Test Site associated with the dry storage facility include the generation of fugitive dust from construction activities (e.g., clearing of land, grading, and road preparation) and vehicle emissions from the heavy equipment utilized during the construction phase of the project. Sources of fugitive dust include:

- transfer of soil to and from haul trucks and storage piles;
- turbulence created by construction vehicles moving over cleared, unpaved surfaces; and
- wind-induced erosion of exposed, barren surfaces.

The construction of this facility would require the clearing of 3.7 ha (7 acres) of land. However, the overall construction impacts to the ambient air quality of the region should be minimal due to the short duration (3 months to 6 years) of the project. Emissions of sulfur dioxide, nitrogen dioxide, and carbon monoxide are assumed to result entirely from diesel exhaust during the construction process. Respirable particulate matter (e.g., PM_{10}) is assumed to be 64 percent of the total suspended particulates estimated for the construction effort. Additionally, wetting controls are assumed to reduce this amount by 50 percent, which is a very conservative estimate.

Table F-87 presents the air quality impacts associated with the construction of the dry storage facility at the Nevada Test Site. Additionally, this table shows that the ambient impacts would be minimal and compliance with existing Federal and State ambient air quality standards would not be adversely affected. Therefore, construction activities would not be expected to have any detrimental effect on the health and safety of the general population. The estimated impacts from construction activities were generated using

Table F-87 Estimated Maximum Concentrations of Criteria Pollutants at the Nevada Test Site Attributable to New Dry Storage Construction

Pollutant	*Averaging Time*	*Ambient Standard*[b]	*Baseline Concentration*[a]	*Construction Activities*
Boundary ($\mu g/m3$):[b, c]				
• Particulate Matter (PM_{10})[a]	24-hour	150	84.90	0.0020
	Annual	50	0.43	0.1107
• Carbon Monoxide	1-hour	40,000	2,748.0	26.756
	8-hour	10,000	2,290.8	3.345
• Sulfur Dioxide	3-hour	1,300	170.3	2.356
	24-hour	365	55.2	0.345
	Annual	80	1.1	0.006
• Nitrogen Oxides	Annual	100	d	0.098

[a] *Source: (DOE, 1995g)*

[b] *64 percent of total suspended particulates is considered to be respirable particulate matter (e.g., PM_{10}) for the construction activities. The standard refers to the actual PM_{10} standard.*

[c] *To convert to $\mu g/ft^3$, multiply by 0.0283*

[d] *No sources indicated*

the U.S. Environmental Protection Agency's regulatory-approved Industrial Source Complex Short-Term Model, Version 2.0 in conjunction with onsite meteorological data from 1991.

Nonradiological emissions are not expected during operation of the new dry storage facility for foreign research reactor spent nuclear fuel. Any emissions associated with dry storage would be directly attributable to front-end wet storage activities only.

Radiological Emissions: No radiological emissions from construction of a new dry storage facility for foreign research reactor spent nuclear fuel are expected. Based on dry fuel drying and storage operations conducted at Idaho National Engineering Laboratory, potential atmospheric releases from the spent nuclear fuel storage facility would consist of minor amounts of particulate radioactive material and larger amounts of gaseous fission products that could escape from the fuel through cladding defects. The majority of radioactive material responsible for fuel and cask internal surface contamination consists of activation products that plate out on the spent nuclear fuel assemblies during reactor operation. This material is dependent on corrosion of structural materials and generally consists of radionuclides such as ^{58}Co, ^{60}Co, ^{50}Fe, etc. This contamination activity would have to be controlled during the cask opening and fuel handling operations to prevent internal personnel exposures. Proper facility ventilation (designed to provide airflow from areas of low contamination to progressively higher contamination) would help provide contamination control. High-efficiency particulate air filters in the facility exhaust would reduce the airborne effluent quantities of this particulate material to quantities that are well within the prescribed limits.

Cask opening and fuel drying operations may also be responsible for the release of significant amounts of ^{3}H, ^{85}Kr, and minor amounts of ^{129}I. The amount of these radionuclides that are released during the cask opening operation depends on the following parameters: (1) the number of spent nuclear fuel clad defects; (2) the spent nuclear fuel material and the diffusion rate of these radionuclides through the fuel matrix for the fuel temperature while in the cask; and (3) the time that the spent nuclear fuel is contained within the cask before opening.

Similarly, for fuel drying operations, the temperature of the drying gas (as well as the parameters discussed above) would cause quantities of ^{3}H, ^{85}Kr, and ^{129}I to be released from the fuel. Charcoal or silver zeolite filters could be used to remove the ^{129}I from the exhaust, but the ^{3}H and ^{85}Kr, being gases, or a gaseous state for the case of tritiated water, would be exhausted to the atmosphere. During spent nuclear fuel storage, small amounts of the gaseous/volatile radionuclides are expected to be released to the environment based on the fuel matrix, clad defects, and storage temperature. Release rates would decrease with storage time due to radioactive decay. It is anticipated that the fuel drying operation would be responsible for the most significant release of these gaseous/volatile radionuclides to the environment.

For this analysis, radiological emissions from the operation of a new dry storage facility for foreign research reactor spent nuclear fuel were calculated based on the methodology and assumptions described in Appendix F, Section F.5. The radiological consequences of air emissions from the operation of the new dry storage facility at the Nevada Test Site are discussed in Section F.4.5.2.1.11. The annual emission releases from the dry storage facility during receipt and unloading and storage are provided in Section F.6.6.1.

F.4.5.2.1.7 Water Resources

The water usage during construction of a new dry storage facility is estimated to be about 7.75 million l (2 million gal). During operations, annual water consumption would be 2.1 million l (550,000 gal) for receipt and handling and 0.4 million l (109,000 gal) for storage. With an annual average water usage of approximately 1,138 million l (301 million gal) for the Nevada Test Site, these amounts represent no more than a 0.2 percent increase in annual water usage. Therefore, a new dry storage facility would have minimal impacts on water resources at the Nevada Test Site.

Best-management practices during construction would prevent sediment runoff or spills of fuels or chemicals. Therefore, construction activities should have no impact on water quality at the Nevada Test Site. The impact on water quality during operations would also be negligible. Existing water treatment facilities at the Nevada Test Site could accommodate any new domestic and process wastewater streams from a new dry storage facility. The expected total flow volumes at the Nevada Test Site would still be well within the design capacities of treatment systems at the Nevada Test Site. A new dry storage facility would meet National Pollutant Discharge Elimination System limits and reporting requirements, so no impact on the water quality of receiving streams is expected.

F.4.5.2.1.8 Ecology

Terrestrial Resources: Radiation doses received by terrestrial biota from foreign research reactor spent nuclear fuel activities would be expected to be similar to those received by man. Although guidelines have not been established for acceptance limits for radiation exposure to species other than man, it is generally agreed that the limits established for humans are also conservative for other species. Evidence indicates that no other living organisms have been identified that are likely to be substantially more radiosensitive than man. Thus, so long as exposure limits protective of man were not exceeded, no significant radiological impact on populations of biota would be expected as a result of spent nuclear fuel activities at Area 5 (DOE, 1995g).

Wetlands: Under the Centralization Alternative, construction of a new dry storage facility would result in the disturbance of approximately 36 ha (90 acres) [3.7 ha or (9 acres) for foreign research reactor spent nuclear fuel], or less than 1 percent of site location. No wetlands are expected to be disturbed because none exist in or around the proposed storage site (DOE, 1995g).

Threatened and Endangered Species: The project area is located within the range of the desert tortoise, a Federally-listed threatened species. Recent pre-activity surveys for other nearby projects have not identified the desert tortoise in the general area of the project site. However, a pre-activity survey for this project would be conducted to determine the presence or absence of the desert tortoise and other species of concern. If present, the desert tortoise could be impacted during construction of the new dry storage facility due to increased vehicular traffic, construction of trenches for utilities, and other temporary construction excavations. Prior to and during construction activities, fencing of the area and removal of tortoises within the fence would decrease the potential to bring harm to the desert tortoise (DOE, 1995g).

DOE has completed consultations with the U.S. Fish and Wildlife Service regarding threatened and endangered species for the proposed construction site of foreign research reactor spent nuclear fuel storage facilities at the Nevada Text Site, as required by the Endangered Species Act.

Construction of a new dry storage facility would have some adverse effects on animal populations. Less mobile animals, such as amphibians, reptiles, and small mammals within the project area would be destroyed during land-clearing activities. Larger mammals and birds in construction and adjacent areas would be disturbed by construction activities and would move to nearby suitable habitat. The long-term survival of these animals would depend on whether the area to which they moved was at or below its carrying capacity. Areas that would be revegetated upon completion of construction would be of minimal value to most wildlife but may be repopulated by more tolerant species (DOE, 1995g).

The Migratory Bird Treaty Act is primarily concerned with the destruction of migratory birds, as well as their eggs and nests. It may be necessary to survey construction sites for the nests of migratory birds prior to construction and/or avoid clearing operations during the breeding season (DOE, 1995g).

Activities associated with operation, such as noise, increased human presence and traffic, and night lighting could affect wildlife living immediately adjacent to the site. While these disturbances may cause some sensitive species to move from the area, most animals should be able to adjust.

F.4.5.2.1.9 Noise

Noises generated on the Nevada Test Site do not propagate offsite at levels that impact the general population. Thus, noise impacts for both the Centralization and Regionalization by Fuel Type and/or Geography Alternatives at the Nevada Test Site would be limited to those resulting from the transportation of personnel and materials to and from the site that affect nearby communities, and those resulting from onsite sources that may affect some wildlife near these sources (DOE, 1995g).

The transportation noises are a function of the size of the work force (e.g., an increased work force would result in increased employee traffic and corresponding increases in deliveries by construction crews). Such noise and activity associated with construction would be expected to have short-term effects on most wildlife (DOE, 1995g).

Under the Centralization Alternative, the projected Nevada Test Site work force would increase by about 48 percent in the years 2000 to 2002, during peak construction, and would decrease thereafter. There would be a corresponding increase in truck, private vehicle, and bus trips to the site. The day-night average sound level at 15 m (50 ft) from U. S. Route 95 would be expected to increase by about 1 decibel.

No change is expected in the community reaction to noise along this route. No mitigation of traffic noise impacts is proposed (DOE, 1995g).

F.4.5.2.1.10 Traffic and Transportation

Construction and operation of a new dry storage facility would involve a small increase in the number of employees commuting to the Nevada Test Site and transportation of foreign research reactor spent nuclear fuel and hazardous chemicals within the site.

The maximum reasonably foreseeable scenario for construction and operations traffic occurs under the Centralization Alternative considered in the Programmatic SNF&INEL Final EIS. This would occur in 2001, when there would be about 3,400 full-time employees, and about 1,200,000 people in the region of influence. None of the future baseline levels of service would change due to spent nuclear fuel-related impacts (DOE, 1995g). These conclusions are equally valid for a new dry storage facility for foreign research reactor spent nuclear fuel.

F.4.5.2.1.11 Occupational and Public Health and Safety

Emission-Related Impacts: Doses that could be received by the public during incident-free operation associated with the receipt and management of the foreign research reactor spent nuclear fuel at the Nevada Test Site would be attributed to emissions of radioactive material that could be carried by wind offsite. The general public would be too far from the locations where handling activities or storage take place to receive any dose from direct exposure. Doses were calculated for the MEI, defined as an individual at the site boundary receiving the maximum exposure, and for the general population within an 80 km (50 mi) radius of the storage facility. These doses would result from incident-free airborne radiological emissions assumed to be released from the unloading of the transportation cask and the storage facility during storage. The methodology and assumptions used for the calculation of the radiological emissions and resulting doses are discussed in Section F.5 of this appendix. Table F-88 summarizes the annual emission-related doses to the public and the associated risks for the MEI and population at the Nevada Test Site. Integrated doses for the duration of a specific implementation period can be obtained by multiplying the annual dose by the number of years in the period.

Table F-88 Annual Public Impacts for Foreign Research Reactor Spent Nuclear Fuel Receipt and Storage at the Nevada Test Site (New Dry Storage)

Facility	*MEI Dose (mrem/yr)*	*MEI Rise (LCF/yr)*	*Population Dose (person-rem/yr)*	*Population Risk (LCF/yr)*
Receipt/Unloading at: • New Dry Storage Facility	0.00076	3.8×10^{-10}	0.00093	4.7×10^{-7}
Storage at: • New Dry Storage Facility	0	0	0	0

Handling-Related Impacts: Workers at the site would receive radiation doses during handling operations (i.e., receiving and unloading the transportation cask). Analysis option 5A involves the receipt of 161 shipments of foreign research reactor spent nuclear fuel from the Idaho National Engineering Laboratory and/or the Savannah River Site, and 193 shipments directly from ports to a new dry storage facility. The assumptions and methodologies used to calculate the doses to a working crew associated with the handling activities of the foreign research reactor spent nuclear fuel are described in Section F.5 of this appendix.

Table F-89 presents the population dose and risk that would be received by the members of the working crew if that working crew handled the total number of transportation casks at the Nevada Test Site. The worker MEI doses and risks were not calculated because of the large uncertainties associated with the assumptions for such calculations. However, the upper bound for such a dose would be equal to the administrative or regulatory limit at the site. For DOE radiation workers, the regulatory limit is 5,000 mrem per year. All these workers would be monitored and if any worker's dose approached this limit, he or she would be rotated into a different job to prevent further exposure. This regulatory limit provides a very conservative upper bound on the radiation dose for the worker MEI. If a single worker received the full 5,000 mrem per year dose for the full 13 years of potential foreign research reactor spent nuclear fuel receipt, then the MEI dose would be 65,000 mrem. For this dose, the associated risk of incurring an LCF would be 2.6 percent.

Table F-89 Handling-Related Impacts to Workers at the Nevada Test Site

	Worker Population Dose (Person-rem)		*Worker Population Risk (LCF)*	
	New Dry Storage Cask	*New Dry Storage Vault*	*New Dry Storage Cask*	*New Dry Storage Vault*
Phase 2	266	113	0.11	0.05

F.4.5.2.1.12 Material, Utility, and Energy Requirements

Construction of a new dry storage facility at the Nevada Test Site would consume 21,800 m^3 (28,500 yd^3) of concrete and 5,200 metric tons (5,750 tons) of steel. The total energy and water requirements during construction are estimated to be 835,000 l (221,000 gal) for fuel, and 7.75 million l (2 million gal) for water.

The annual utility and energy requirements during operations are shown in Table F-90. These requirements represent a small percent of current requirements for the Nevada Test Site. No new generation or treatment facilities would be necessary, and connections to existing networks would require only short tie-in lines. Increases in consumption would be minimal because overall activity on the Nevada Test Site is expected to decrease because of changes in site mission and a general reduction in employment.

Table F-90 Annual Utility and Energy Requirements for New Dry Storage at the Nevada Test Site

Commodity	*Baseline Site Usage*	*Dry Storage Usage*	*Percent Increase*
Electricity (MW-hr/yr)	176,440	800 - 1,000	0.6 percent
Fuel (l/yr)	[a]	0	0 percent
Water (l/yr)	1,138,000,000	1,590,000[b] 400,000[c]	0.14 percent[b] 0.04 percent[b]

[a] *The majority of energy used at the Nevada Test Site is provided by electricity.*

[b] *During receipt and handling*

[c] *During storage*

F.4.5.2.1.13 Waste Management

Construction of a new dry storage facility at the Nevada Test Site would generate 1,800 m^3 (2,400 yd^3) of debris. The annual quantities of waste generated during operations are shown in Table F-91. These quantities represent a very small percent increase above current levels at the Nevada Test Site. Existing waste management storage and disposal activities at the Nevada Test Site could accommodate the waste generated by a new dry storage facility. Therefore, the impact of this waste on existing Nevada Test Site waste management capacities would be minimal.

Table F-91 Annual Waste Generated for New Dry Storage at the Nevada Test Site

Waste Form	Baseline Site Generation	Dry Storage Generation	Percent Increase
High-Level (m^3/yr)	0	none	0 percent
Transuranic (m^3/yr)	0	none	0 percent
Solid Low-Level (m^3/yr)	10,845	22[a] 1[b]	0.20 percent[a] 0.01 percent[b]
Wastewater (l/yr)	11,000,000	1,590,000[a] 400,000[b]	14.4 percent[a] 3.6 percent[b]

[a] *During receipt and handling*

[b] *During storage*

F.4.5.2.2 Wet Storage

Analysis option 5B involves long-term wet storage of foreign research reactor spent nuclear fuel at the Nevada Test Site. This storage option would require the construction of a new wet storage facility.

F.4.5.2.2.1 Land Use

A new wet storage facility would be located in Area 5 in the southeastern portion of the Nevada Test Site. The land in this area can be characterized as sparsely vegetated desert, ready for development. Use of Area 5 for foreign research reactor spent nuclear fuel storage would be consistent with existing land use plans, which designate this area for general use. Construction activities, including laydown areas, would disturb 2.8 ha (7 acres) of land. A new wet storage facility would occupy 3,800 m^2 (41,000 ft^2) of land and would move 18,000 m^3 (24,000 yd^3) of soil. Neither construction nor operation of a new wet storage facility at any of the areas would significantly impact land use patterns on the Nevada Test Site.

F.4.5.2.2.2 Socioeconomics

As discussed in Section F.3.2 the total capital cost of a new wet storage facility is estimated to be $449 million. Construction activities are projected to take 4 years. Assuming that the capital cost is evenly distributed over this 4-year period, the annual expenditures would be about $112.2 million. This represents approximately 79.5 percent of the estimated FY 1995 total expenditures for the Nevada Test Site (141 million). The relative socioeconomic impact from annual construction expenditures on the region of influence would be substantial. The annual operations costs of a new wet storage facility are estimated to be $23.3 million for receipt and handling and $3.5 million for storage. These costs represent about 16.5 percent and 2.5 percent of FY 1995 total expenditures for the Nevada Test Site. The relative socioeconomic impact from annual operation expenditures on the region of influence would be positive.

Direct employment associated with construction of a new wet storage facility is estimated to be 157 persons. The relative socioeconomic impact from direct construction employment on the region of influence would be small. In addition, when compared to the projected FY 1995 work force at the Nevada Test Site of approximately 4,000 persons, the relative socioeconomic impact of this temporary increase in construction employment would be insignificant. Direct employment associated with operations of a new wet storage facility is estimated to be 30 persons. The relative socioeconomic impact of this increase in operations employment would be insignificant to both the region of influence and the Nevada Test Site.

F.4.5.2.2.3 Cultural Resources

Impacts to cultural resources would be the same as for new dry storage (Section F.4.5.2.1.3).

F.4.3.2.2.4 Aesthetic and Scenic Resources

Impacts to aesthetic and scenic resources would be the same as for new dry storage (Section F.4.5.2.1.4).

F.4.5.2.2.5 Geology

Impacts to geology would be the same as for new dry storage (Section F.4.5.2.1.5).

F.4.5.2.2.6 Air Quality

Nonradiological Emissions: Construction of a new wet storage facility would necessitate the clearing and grading of approximately 3 ha (7 acres) of land. In comparison, approximately 4 ha (10 acres) of land would be disturbed by new dry storage construction. Therefore, air quality impacts associated with wet storage construction would be bound by those associated with dry storage construction, as presented in Section F.4.5.2.1.6.

No nonradiological emissions from the operation of the new wet storage facility are expected.

Radiological Emissions: Incident-free airborne releases from the new wet storage facility would be limited to radioactive noble gases and some radioactive iodine which could be released from the stored fuel prior to canning. The airborne materials released to the building atmosphere during incident-free operations would be filtered by the building heating and ventilation system. Radioactive and nonradioactive effluent gases would be routed through double-banked high-efficiency particulate air filters prior to release to the environment through an exhaust air system. The high-efficiency particulate air filter would have a minimum efficiency of 99.97 percent for 0.3 micron diameter particulates and would allow in-place dioctyl phthalate testing.

The new wet storage facility would discharge all ventilated gas, except truck exhaust, to the facility exhaust system. Truck exhaust would be discharged directly to the environment during cask off-loading operations in the truck receiving area. The exhaust air system would employ a detector to monitor ^{137}Cs. For other building areas which would be sources of airborne radioactive contamination, the heating, ventilating, and air conditioning system would be designed to maintain airflow from areas of low potential contamination into areas of higher potential contamination. These airborne effluents would be required to be below the radioactivity concentration guides listed in DOE Order 5480.1B for both onsite and offsite concentrations (DOE, 1989b).

Air emissions from the new wet storage facility are expected to be similar to the air emissions from the CPP-603 at Idaho National Engineering Laboratory. The annual air emission for the CPP-603 was designed to result in ground-level concentrations of less than 0.003 percent of DOE 5480.1B limits for uncontrolled areas. Radiological emissions from the operation of the wet storage facility were calculated based on the methodology and assumptions used in Appendix F, Section F.6. The annual emission releases from the wet storage facility during the receipt and unloading, and storage are provided in Section F.6.6.1.

F.4.5.2.2.7 Water Resources

The annual water usage during construction and operation of a new wet storage facility is estimated to be about 1.9 million l (1.2 million gal) and 2.7 million l (720,000 gal), respectively. With an annual average water usage of approximately 1,138 million l (301 million gal) for the Nevada Test Site, these amounts represent an increase of about 0.17 percent and 0.23 percent, respectively. Therefore, a new wet storage facility would have minimal impact on water resources at the Nevada Test Site.

Best-management practices during construction would prevent sediment runoff or spills of fuels or chemicals. Therefore, construction activities should have no impact on water quality at the Nevada Test Site. The impact on water quality during operations would also be negligible. Existing water treatment facilities at the Nevada Test Site could accommodate any new domestic and process wastewater streams from a new wet storage facility. The expected total flow volumes at the Nevada Test Site would still be well within the design capacities of treatment systems at the Nevada Test Site. A new wet storage facility would meet National Pollutant Discharge Elimination System limits and reporting requirements, so no impact on the water quality of receiving streams is expected.

F.4.5.2.2.8 Ecology

Impacts to the ecology would be the same as for new dry storage (Section F.4.5.2.1.8).

F.4.5.2.2.9 Noise

Impacts from noise would be the same as for new dry storage (Section F.4.5.2.1.9).

F.4.5.2.2.10 Traffic and Transportation

Impacts from traffic and transportation would be the same as for new dry storage (Section F.4.5.2.1.10).

F.4.5.2.2.11 Occupational and Public Health and Safety

Emission-Related Impacts: Doses that could be received by the public during incident-free operation associated with the receipt and management of the foreign research reactor spent nuclear fuel at the Nevada Test Site would be attributed to emissions of radioactive material that could be carried by wind offsite. The general public would be too far from the locations where handling activities or storage take place to receive any dose from direct exposure. Doses were calculated for the MEI, defined as an individual at the site boundary receiving the maximum exposure, and for the general population within an

80 km (50 mi) radius of the storage facility. These doses would result from incident-free airborne radiological emissions assumed to be released from the unloading of the transportation cask and the storage facility during storage. The methodology and assumptions used for the calculation of the radiological emissions and resulting doses are discussed in Section F.6 of this appendix. Table F-92 summarizes the annual emission-related doses to the public and the associated risks for the MEI and population at the Nevada Test Site. Integrated doses for the duration of a specific implementation period can be obtained by multiplying the annual dose by the number of years in the period.

Table F-92 Annual Public Impacts for Foreign Research Reactor Spent Nuclear Fuel Receipt and Storage at the Nevada Test Site (Implementation Alternative 5 of Management Alternative 1)

Facility	*MEI Dose (mrem/yr)*	*MEI Risk (LCF/yr)*	*Population Dose (person-rem/yr)*	*Population Risk (LCF/yr)*
Receipt/Unloading at: • New Wet Storage Facility	0.00052	2.6×10^{-10}	0.00052	2.6×10^{-7}
Storage at: • New Wet Storage Facility	4.0×10^{-9}	2.0×10^{-15}	4.7×10^{-9}	2.4×10^{-12}

Handling-Related Impacts: Workers at the site would receive radiation doses during handling operations (i.e., receiving and unloading the transportation cask), transferring the foreign research reactor spent nuclear fuel from one facility to another, or preparing the foreign research reactor spent nuclear fuel for shipment offsite. Analysis option 5B involves the receipt of 161 shipments of foreign research reactor spent nuclear fuel from the Idaho National Engineering Laboratory and/or the Savannah River Site and 193 shipments directly from ports into a new wet storage facility. The assumptions and methodologies used to calculate the doses to a working crew associated with the handling activities of the foreign research reactor spent nuclear fuel are described in Section F.5 of this appendix.

Table F-93 presents the population dose and risk that would be received by the members of the working crew if that working crew handled the total number of transportation casks at the Nevada Test Site. The worker MEI doses and risks were not calculated because of the large uncertainties associated with the assumptions for such calculations. However, the upper bound for such a dose would be equal to the administrative limits at the site. For DOE radiation workers, the regulatory limit is 5,000 mrem per year. All these workers would be monitored and if any worker's dose approached this limit, he or she would be rotated into a different job to prevent further exposure. This regulatory limit provides a very conservative upper bound on the radiation dose for the worker MEI. If a single worker received the full 5,000 mrem per year dose for the full 13 years of potential foreign research reactor spent nuclear fuel receipt, then the MEI dose would be 65,000 mrem. For this dose, the associated risk of incurring an LCF would be 2.6 percent.

Table F-93 Handling-Related Impacts to Workers at the Nevada Test Site (Implementation Alternative 5 of Management Alternative 1)

	Worker Population Dose (Person-rem)	*Worker Population Risk (LCF)*
	New Wet Storage	*New Wet Storage*
Phase 2	109	0.04

F.4.5.2.2.12 Material, Utility, and Energy Requirements

Construction of a new wet storage facility at the Nevada Test Site would consume 12,400 m^3 (16,260 yd^3) of concrete and 3,100 metric tons (3,443 tons) of steel. The total energy and water requirements during construction are estimated to be 600,000 l (159,000 gal) for fuel, and 4.4 million l (1.2 million gal) for water. The annual utility and energy requirements during operations are shown in Table F-94. These requirements represent a small percent of current requirements for the Nevada Test Site. No new generation or treatment facilities would be necessary, and connections to existing networks would require only short tie-in lines. Increases in consumption would be minimal because overall activity on the Nevada Test Site is expected to decrease because of changes in site mission and a general reduction in employment.

Table F-94 Annual Utility and Energy Requirements for Wet Storage at the Nevada Test Site (Implementation Alternative 5 of Management Alternative 1)

Commodity	Baseline Site Usage	Wet Storage Usage	Percent Increase
Electricity (MW-hr/yr)	176,440	800 - 1,000	0.84 percent
Fuel (l/yr)	[a]	0	0 percent
Water (l/yr)	1,139,000,000	2,700,000[b] 1,500,000[c]	0.23 percent 0.13 percent

[a] *The majority of energy used at the Nevada Test Site is provided by electricity.*

[b] *During receipt and handling*

[c] *During storage*

F.4.5.2.2.13 Waste Management

Construction of a new wet storage facility at the Nevada Test Site would generate 2,600 m^3 (10,300 yd^3) of debris. The annual quantities of waste generated during operations are shown in Table F-95. These quantities represent a very small percentage increase above current levels at the Nevada Test Site. Existing waste management storage and disposal activities at the Nevada Test Site could accommodate the waste generated by a new wet storage facility. Therefore, the impact of this waste on the existing the Nevada Test Site waste management capacities would be minimal.

Table F-95 Annual Waste Generated for Wet Storage at the Nevada Test Site (Implementation Alternative 5 of Management Alternative 1)

Waste Form	Baseline Site Generation	Wet Storage Generation	Percent Increase
High-Level (m^3/yr)	0	none	0 percent
Transuranic (m^3/yr)	0	none	0 percent
Solid Low-Level (m^3/yr)	10,845	16[a] 1[b]	0.15 percent 0.01 percent
Wastewater (l/yr)	11,000,000	1,590,000[a] 400,000[b]	14.5 percent 3.6 percent

[a] *During receipt and handling*

[b] *During storage*

F.4.5.3 Accident Analysis

An evaluation of incident-free operations and hypothetical accidents at the Nevada Test Site is presented here based on the methodology in Appendix F, Section F.6. The evaluation assessed the possible radiation exposure to individuals and general population due to the release of radioactive materials. The analyses are based on the same operations carried out at the different potential storage locations and the same accidents at any of the sites evaluated. Information concerning radiological doses to individuals and the general population are the same as set forth in Section F.4.1.3.

Table F-96 presents the frequency and consequences in terms of mrem or person-rem, of postulated accidents to the offsite MEI, NPAI, and offsite population for the 95th-percentile meteorological conditions using the assumptions and input values discussed above. The worker doses are calculated only for the 50th-percentile meteorology. This is an individual assumed to be 100 m (330 ft) downwind of the accident. DOE did not estimate the worker population dose.

Table F-96 Frequency and Consequences of Accidents at the Nevada Test Site

	Frequency (per year)	*Consequences*			
		MEI (mrem)	*NPAI (mrem)*	*Population (person-rem*	*Worker (mrem)*
Dry Storage Accidents[a]					
• Spent Nuclear Fuel Assembly Breach	0.16	1.7	0.31	1.5	20
• Dropped Fuel Cask	0.0001	0.11	0.0014	0.40	0.089
• Aircraft Crash w/Fire	1×10^{-6}	180	1.2	250	87

[a] *E-MAD and New Dry Storage Facility*

Multiplying the frequency of each accident times its consequences and converting the radiation doses to LCF yields the annual risks associated with each potential accident at the Nevada Test Site. These annual risks are multiplied by the maximum duration of this implementation alternative at each site to obtain conservative estimates of risks for the Nevada Test Site. These risk estimates are presented in Table F-97.

Table F-97 Annual Risks of Accidents at the Nevada Test Site

	Consequences			
	MEI (LCF/yr)	*NPAI (LCF/yr)*	*Population (LCF/yr)*	*Worker (LCF/yr)*
Dry Storage Accidents[a]				
• Spent Nuclear Fuel Assembly Breach	1.4×10^{-7}	2.5×10^{-8}	0.00012	0.0000013
• Dropped Fuel Cask	5.5×10^{-12}	7.0×10^{-14}	2.0×10^{-8}	3.6×10^{-12}
• Aircraft Crash w/Fire	9.0×10^{-11}	6.0×10^{-13}	1.3×10^{-7}	3.5×10^{-11}

[a] *E-MAD and New Dry Storage Facility*

Table F-98 presents the frequency and consequences of the accidents analyzed for each site for wet storage (Implementation Alternative 5 of Management Alternative 1). Multiplying the frequency of each accident times its consequences at each site and converting the radiation doses to LCF yields the annual risks associated with each potential accident at the Nevada Test Site. These annual risks are multiplied by the maximum duration of this implementation alternative at each site to obtain conservative estimates of risks at the Nevada Test Site. Table F-99 presents the risk estimates from this implementation.

F.4.5.3.1 Secondary Impact of Radiological Accidents at the Nevada Test Site

In the event of an accidental release of radioactivity, there is a potential for impacts to land uses, cultural resources, water quality, ecology, national defense, and local economies (secondary impacts). For this analysis, secondary impacts of radiological accidents involving foreign research reactor spent nuclear fuel have been qualitatively assessed based on the calculations presented in Section F.4.5.3. Radiological

Table F-98 Frequency and Consequences of Accidents at the Nevada Test Site (Implementation Alternative 5 of Management Alternative 1)

	Frequency (per year)	Consequences			
		MEI (mrem)	NPAI (mrem)	Population (person-rem)	Worker (mrem)
• Spent Nuclear Fuel Assembly Breach	0.16	0.054	0.0016	0.33	0.10
• Accidental Criticality	0.0031	88	15	54	1,300
• Aircraft Crash	1×10^{-6}	29	4.2	61	290

Table F-99 Annual Risks of Accidents at the Nevada Test Site (Implementation Alternative 5 of Management Alternative 1)

	Consequences			
	MEI (LCF/yr)	NPAI (LCF/yr)	Population (LCF/yr)	Worker (LCF/yr)
• Spent Nuclear Fuel Assembly Breach	4.2×10^{-9}	1.3×10^{-10}	0.000026	6.4×10^{-9}
• Accidental Criticality	1.4×10^{-7}	2.3×10^{-8}	0.000084	0.000016
• Aircraft Crash	1.5×10^{-11}	2.1×10^{-12}	3.1×10^{-8}	1.2×10^{-10}

accidents that resulted in doses to the MEI of less than the annual Federal radiological exposure limit for the public of 100 mrem (10 CFR Part 20) were considered to have no secondary impacts.

The MEI dose provides a measure of the air concentration and radionuclide deposition at the receptor location. As such, it can be used to express the level of contamination from a given radiological accident. In estimating the human health effects from radiological exposure (as presented in Section F.4.1.3), the MEI dose evaluates four pathways: (1) air immersion, (2) ground surface, (3) inhalation, and (4) ingestion. In estimating the environmental effects from radiological exposure, however, only the air immersion and ground surface pathways need be considered.

At the Nevada Test Site, the radiological accident with the highest MEI dose is the aircraft crash into a dry storage facility with fire (Table F-96). For this accident, the MEI dose would be 180 mrem. For the air immersion and ground surface pathways only, the dose would be 1.0 mrem, which is less than the 100 mrem limit used in this analysis. Therefore, no secondary impacts to land uses, cultural resources, water quality, ecology, national defense, and local economies from radiological accidents involving foreign research reactor spent nuclear fuel storage would be expected at the Nevada Test Site.

F.4.5.4 Cumulative Impacts at the Nevada Test Site

The section presents the cumulative impacts of the proposed action, potential impacts of other contemplated DOE actions, and current activities at the site. A major portion of the presentation is based on information included in the Programmatic SNF&INEL Final EIS (DOE, 1995g) and the Tritium Supply and Recycling Final EIS (DOE, 1995a). The Programmatic SNF&INEL Final EIS includes the quantitative impacts from a proposed Expended Core Facility at the site. The Nevada Test Site is also considered in the storage and disposition of weapons-usable fissile materials program which could affect the site environment. The impacts from this program have not been determined sufficiently at this time to allow impact evaluation.

Table F-100 Cumulative Impacts at the Nevada Test Site

Environmental Impact Parameter	*FRR SNF Contribution*	*Other Activities*[a]	*Cumulative Impact*
Land Use (acres)	9	314,393[b]	314,402
Socioeconomics (persons)	190[c]/30[d]	2,662[c]/1,000[d]	2,852[c]/1,030[d]
Air Quality (nonradiological)	See Table F-100A	See Table F-100A	See Table F-100A
Occupational and Public Health and Safety			
• MEI Dose (rem/yr)	$7.6x10^{-7}$	0.00031	0.00031
LCF (per year)	$3.8x10^{-10}$	$1.55x10^{-7}$	$1.55x10^{-7}$
• Population Dose (person-rem/yr)	0.00093	0.095	0.095
LCF (per year)	$4.7x10^{-7}$	.00047	0.000047
• Worker Collective Dose (person-rem/yr)	8.9[e]	81	89.9
LCF (per year)	0.0036	0.032	0.035
Energy and Water Consumption			
• Electricity (MW-hr/yr)	1,000	4,019,000[f]	4,020,000
• Fuel (million l/yr)	0	6,129	6,129
• Water (million l/yr)	2.2	2,563	2,565
Waste Generation			
• High-Level (m^3/yr)	0	0	0
• Low-Level (m^3/yr)	22	44,578	44,600
• Mixed/Hazardous (m^3/yr)	0	252	252
• Transuranic (m^3/yr)	0	16	16

[a] *Other activities include existing activities, DOE-owned spent fuel management activities, construction and operation of an Expended Core Facility, and construction and operation of a tritium production facility.*

[b] *Existing developed land area is 314,000 acres*

[c] *Increase over baseline (3,300 persons) during construction activities*

[d] *Increase over baseline (3,300 persons) during operation activities*

[e] *The dose is due to the handling of foreign research reactor spent nuclear fuel during receipt, averaged over 30 years*

[f] *Major portion is the requirement for electricity by the tritium production (accelerator) facility (3,740,000 MW-hr/yr)*

Tables F-100 and F-100A summarize the cumulative impacts for land use, socioeconomics, air quality, occupational and public health and safety, energy and water consumption and waste generation at the site. Table F-100 also presents the contribution from the storage of foreign research reactor spent nuclear fuel to the cumulative impacts at the Nevada Test Site. For the purposes of this analysis, both the contributions from management of foreign research reactor spent nuclear fuel and the cumulative impacts were maximized by selecting the Centralization Alternative of the Programmatic SNF&INEL Final EIS at the Nevada Test Site.

As shown in Table F-100, the contribution from storage of foreign research reactor spent nuclear fuel to the cumulative impacts (under the Centralization Alternative) at the Nevada Test Site would be minimal. The Programmatic SNF&INEL Final EIS concludes that the implementation of any of the alternatives (including the Centralization Alternative) for the DOE spent nuclear fuel management program would not be expected to significantly contribute to cumulative impacts (DOE, 1995g). This conclusion is also valid for the implementation of any of the alternatives considered in this EIS for storage of foreign research reactor spent nuclear fuel at the Nevada Test Site.

Table F-100A Estimated Maximum Nonradiological Cumulative Ground-Level Concentrations of Criteria and Toxic Pollutants at the Nevada Test Site[a]

Pollutant	Averaging Time	Regulatory Standard ($\mu g/m^3$)	Cumulative Concentration[b] ($\mu g/m^3$)
Carbon Monoxide	1-hour	40,000	2,815 (7%)
	8-hour	10,000	2,306 (23%)
Nitrogen Oxides	Annual	100	4.2 (4.2%)
Sulfur Dioxide	3-hour	1300	173.6 (13.3%)
	24-hour	365	55.5 (15.2%)
	Annual	80	1.1 (1.3%)
Particulate Matter (PM_{10})	24-hr	150	85 (56.6%)
	Annual	50	0.54 (1.1%)

[a] *Concentrations represent activities from: foreign research reactor spent nuclear fuel management, DOE-owned spent nuclear fuel management, construction and operation of an Expended Core Facility, and construction and operation of a tritium production and recycling facilities*

[b] *Number in parentheses indicate the percentage of the Regulatory Standard*

F.4.5.5 Unavoidable Adverse Environmental Impacts

Construction of the potential new foreign research reactor spent nuclear fuel storage facilities would require the disturbance of approximately 4 ha (10 acres) of undeveloped land. Although this represents less than one percent of the undeveloped land on the Nevada Test Site, it would eliminate potential terrestrial wildlife habitat, including habitat potentially suitable for the Federally-listed desert tortoise. It would also require the dedication of a small land parcel potentially suitable for other construction projects, but similar land parcels are abundant on the Nevada Test Site.

F.4.5.6 Irreversible and Irretrievable Commitments of Resources

Construction and operation of new foreign research reactor spent nuclear fuel facilities would require commitments of electrical energy, fuel, concrete, steel, sand, gravel and miscellaneous chemicals. Groundwater to operate the foreign research reactor spent nuclear fuel facilities would be withdrawn from an aquifer that is presently experiencing localized overdraught. Further studies would be necessary to quantify any irreversible effects on future groundwater availability attributable to spent nuclear fuel withdrawals from that aquifer. The land dedicated to the foreign research reactor spent nuclear fuel facilities would become available for other rural uses following closure and decommissioning.

F.4.5.7 Mitigation Measures

Mitigation is addressed in general terms and describes typical measures that the Nevada Test Site could implement. The analyses indicate that the environmental consequences attributable to foreign research reactor spent nuclear fuel management activities at the site would be minimal in most environmental media.

Pollution Prevention: The DOE Nevada Field Office published a Waste Minimization and Pollution Prevention Awareness Plan in June 1991 to reduce the quantity and toxicity of hazardous, mixed, and radioactive wastes generated at DOE Nevada Field Office facilities. The plan is designed to reduce the possible pollutant releases to the environment and thus increase the protection of employees and the public. All DOE Nevada Field Office contractors and the Nevada Test Site users that exceed the Environmental Protection Agency criteria for small-quantity generators are establishing their own waste minimization and pollution prevention awareness programs that are implemented by the DOE Nevada Field Office plan. Contractor programs ensure that waste minimization activities are in accordance with Federal, State, and local environmental laws and regulations, and DOE orders (DOE, 1995g).

Additional goals include the promotion and use of nonhazardous materials, establishment of a baseline of waste generation data, calculations of annual reductions of waste generated, and implementation of regulatory programs. Goals also include incorporation of waste minimization concepts and technologies in planning and design of new processes and facilities and in upgrades of existing facilities. A waste minimization task force composed of representatives from each contractor and the Nevada Test Site user has been established to coordinate DOE/Nevada Test Site waste minimization and pollution awareness activities (DOE, 1995g).

Socioeconomics: To reduce construction- and operation-related impacts, possible coordination with local communities could address potential impacts from increased labor and capital requirements. The knowledge of the extent and effect of growth due to foreign research reactor spent nuclear fuel management activities could greatly enhance the ability of affected jurisdictions to plan effectively. Effective planning would address changes in levels of service for housing, infrastructure, utilities, transportation, and public services and finances (DOE, 1995g).

To alleviate potential impacts associated with the in-migration of labor, local labor force availability could be increased through various employment training and referral systems currently provided by the Nevada Test Site. The goal of these systems would be to reduce the potential for in-migration of labor to support foreign research reactor spent nuclear fuel management activities (DOE, 1995g).

Cultural Resources: Consultation with the Nevada State Historic Preservation Office prior to project implementation is required under Section 106 of the National Historic Preservation Act of 1966. The State Historic Preservation Office may recommend that further archaeological studies be conducted throughout the construction area to verify that there are no archaeological sites subject to disturbance (DOE, 1995g).

Water Resources: The foreign research reactor spent nuclear fuel facilities would have to be located and constructed to minimize floodplain impacts and to avoid floodplains to the maximum extent possible, as required by Executive Order 11988 (Floodplain Management) and DOE orders. Site-specific surveys would be performed to determine locations of flooding elevations more accurately (DOE, 1995g).

Accidents: The foreign research reactor spent nuclear fuel storage facilities would be designed to comply with current Federal, State, and local laws, DOE orders, and industrial codes and standards. This would provide facilities that are highly resistant to the effects of severe natural phenomena, including earthquakes, floods, tornadoes, and high winds, as well as credible events appropriate to the site, such as fires and explosions and manmade threats to its continuing structural integrity for containing materials (DOE, 1995g).

An emergency preparedness plan would also be developed to lower the potential consequences of an accident to workers and the public. All workers receive evacuation training to ensure timely and orderly personnel movement away from high-risk areas. Plans and arrangements with local authorities would also be in place to evacuate the general public that may be at risk of exposure to hazardous materials accidentally released (DOE, 1995g).

F.5 Occupational Radiation Impacts from Receipt and Handling of Foreign Research Reactor Spent Nuclear Fuel

Occupational exposure to gamma radiation would depend largely on the operational history of the spent nuclear fuel elements to be stored in the facility and the length of time that these elements have been allowed to decay from the time that they were taken out of the reactor until they were placed in the cask for shipment to the storage facility. Normally, the decay time for fuel elements is established so that the gamma heating in the transportation cask is within specification and the radiation field on the outside cask surface is 200 mrem per hour or less. Special shipments can be made, however, with higher cask surface radiation fields, provided other requirements are met. Radiation exposures to personnel during receiving operations and surveys would depend on the level of radiation that is measurable on the exterior (surface) of the transportation cask. These initial operations are anticipated to provide the majority of personnel exposure since the remaining operations would be remote and could take advantage of the shielding built into the facility.

Realistic annual occupational radiation exposure estimates for facility operation can be performed once the following have been established:

- determination of accurate decay-time averaged values for the spent nuclear fuel,
- development of shielding characteristics for transportation casks for the spent nuclear fuel to be shipped to the facility,
- definition of personnel requirements for each of the individual operations to be accomplished within the facility, and
- completion of a time-motion study for the spent nuclear fuel element movement through the preliminary design of the facility.

The analyses in this appendix are based on a best estimate of the above conditions. The potential impacts are given in doses per cask shipment, so that the results can be simply multiplied by the total number of shipments for each potential storage arrangement.

Wet Storage: Occupational radiation exposure from the receipt, handling and storage of foreign research reactor spent nuclear fuel at a wet storage facility is treated in a generic way for all potential management sites, since the activities are essentially identical regardless of where the facility is located. It is based on actual handling experience of spent nuclear fuel at the Idaho National Engineering Laboratory and the Savannah River Site.

The workers involved with each cask were assumed to include the shipping agent, shift foremen, health physics technicians, and equipment operators. The equipment operators include onsite workers who remove each cask from its shipping container and transport it to the receiving bay, and those who perform most of the actual labor involved thereafter, such as transferring the spent nuclear fuel to storage and decontaminating the empty cask prior to returning it to the owners. Thus, while the assessment does not distinguish between them, the operators are a diverse group of workers whose distinct duties make it unlikely that the same operators could receive all of the calculated individual doses discussed below. As a result, it was assumed that the two foremen and two operators involved in handling the spent nuclear fuel casks outside the receiving facility would be different than the two foremen and two operators working inside the facility (the health physics technicians were assumed to be the same). This provides a conservative estimate of 12 workers.

In order to estimate the occupational radiation doses from the handling of foreign research reactor spent nuclear fuel transportation casks at the spent nuclear fuel management sites, it was necessary to develop a curve of dose rate versus distance for these casks. Historical data based on 44 research reactor spent nuclear fuel transportation cask receipts at either the Savannah River Site or the Idaho National Engineering Laboratory were obtained and evaluated. This historical data showed an average measured dose rate of approximately 2.3 mrem per hour at 1 m (3.3 ft) from the surface of the transportation cask. One cask, however, was measured to be 20 mrem per hour at 1 m (3.3 ft). To encompass this historical data, including the highest measured dose rate cask, an analysis was performed that assumed a dose rate of 23 mrem per hour at 1 m (3.3 ft) from the cask surface. It should be noted that, in the unlikely event that a higher dose rate transportation cask was received at the management site, radiological control procedures for as low as reasonably achievable limits would be utilized to ensure that the worker doses would be minimized. Dose rate reduction is usually accomplished by a combination of restrictions on time, distance from the source, and the provision of additional radiation shielding.

The plot of bounding transportation cask dose rate versus distance in Figure F-50 was developed using the ZYLIND computer code and appropriate conservative methodology. ZYLIND (RSIC, 1990) is a shielding computer code that uses the point kernel method to calculate photon dose rates from a cylindrical source and shield geometry. ZYLIND was developed in Germany in 1989 and then released to the Oak Ridge National Laboratory Radiation Shielding Information Center. ZYLIND has been extensively validated by comparison to measured dose rates from several hundred cylindrical containers with radioactive materials. ZYLIND calculated dose rates that were conservative and within 10 to 20 percent of the measured dose rates. ZYLIND allows the photon energy source to be divided into up to 20 energy groups from 0 to 10 million electron volts (Mev), allows up to eight materials regions, and includes mass attenuation and dose buildup information for a wide range of shielding materials.

The methodology used in calculating bounding transportation cask dose rates had four underlying assumptions. First, it was assumed that the dose rate at 1 m (3.3 ft) from the cask surface is 23 mrem per hour. Second, neutron dose rates from foreign research reactor spent nuclear fuel were assumed to be negligible and the only dose was assumed to be due to gamma (photon) radiation. A third assumption was that the foreign research reactor spent nuclear fuel source term inside a cask could be conservatively simulated by a single 1.0 Mev gamma energy group. Traditional NRC source terms (DiNunno et al, 1962) for spent nuclear fuel fission products assume an average gamma energy of 0.7 Mev. By using 1.0 Mev, the average gamma energy is expected to be conservatively bounded. Finally, it was assumed that the use of a point kernel cylindrical source-shield computer code (i.e., ZYLIND) would conservatively calculate the dose rates from a transportation cask.

The principal inputs for the calculation were the ZYLIND computer code manual (Radiation Shielding Information Center ZYLIND) and the U.S. Department of Transportation Certificates of Competent Authority for seven transportation cask designs that are likely to be used for the shipment of foreign research reactor spent nuclear fuel. These seven designs are: TN7, GNS-11, LHRL-120, NAC/LWT, PEGASE (IU-04), BMI-1, and GE-2000. These transportation casks are described in Appendix B, Section B.2. The U.S. Department of Transportation Certificates of Competent Authority provided geometry data on the cask inside cavity dimensions and the thickness and material composition of shielding adjacent to the cavity for each design.

With the cask geometry information, a set of ZYLIND calculations was performed for each design. An initial 1.0 Mev gamma source was estimated and ZYLIND was executed to calculate the dose rate at 1 m (3.3 ft) from the cask surface. This source was iterated upon until the 1 m (3.3 ft) dose rate equaled 23 mrem per hour. After this source was determined, the same source and cask geometry were rerun to calculate the dose rate at distances of from 0-50 m (0-164 ft) from the cask surface. This process was repeated for each of the transportation cask designs. The resulting dose rates at distance for each cask design were compared and the highest dose rate response at all distances was synthesized from this data to produce Figure F-50.

Table F-101 shows the actual dose rates encountered during receipt and handling for essentially all of the foreign research reactor spent nuclear fuel casks, which are expected to be one to two orders of magnitude lower than the limit, based on actual experience with foreign research reactor spent nuclear fuel in the past.

Table F-102 presents the wet storage collective dose for unloading one transportation cask using time, distance, and personnel data from the Idaho National Engineering Laboratory and the dose rate curve in Figure F-50. The total worker dose per transportation cask was calculated to be 0.31 person-rem. The actual distances for each worker are based on conservative estimates of actual work experience that would reflect an as low as reasonably achievable Radiation Protection Program as required by DOE regulation (10 CFR 835).

Generic Dry Cask Storage: The receipt, handling, and storage occupational radiation doses (deep dose equivalents) for dry storage are also treated in a generic way, since the operation of the general facility designed for dry storage would be the same at any management site. The assessment is based on Pressurized Water Reactor spent nuclear fuel from the reactor's spent nuclear fuel storage pool to an NRC-licensed dry storage facility at the Calvert Cliffs nuclear power plant in Maryland. The system employed is the horizontal module system (NUHOMS), which was selected for this assessment for two reasons: (1) it is a current, regulatory-approved design that is readily available for foreign research reactor spent nuclear fuel dry storage, and (2) the worker dose rates calculated for the system are among the highest of the current systems now in use for storage of commercial spent nuclear fuel. As a result, the system analysis provides a reasonably conservative estimate for storage of foreign research reactor spent nuclear fuel in NUHOMS and a reasonable upperbound assessment for all other foreign research reactor spent nuclear fuel generic dry storage. The Calvert Cliffs Safety Analysis Report does not identify each category of worker associated with receipt, handling, transfer, and storage of spent nuclear fuel. As a result, for this assessment, the doses (deep dose equivalent) were assumed to be the same for all workers (titled "operators" in the assessment). However, it would appear from the work activities that it cannot be the same operators who support each of the activities. As a result, job titles comparable to those considered for wet storage have been defined in order to determine the average worker dose per cask. Therefore, it is assumed that the following categories of workers are involved: foremen (2), health physics technicians (2), equipment operators for the storage pool activities (2), and different equipment operators for the one-site transport and transfer of the spent nuclear fuel from the transfer cask to the dry storage cask (3), welders (2), helium leak test technician (1), and dye penetrant test technician (1). Each of the distances listed is the average distance for all of the workers involved in each one of the 25 specific activities associated with receipt, handling, transfer, and dry storage. Thus, for example, the first activity [loading fuel into the container (dry shielded canister)], would involve four workers (one foreman, one health physics technician, and two operators) in the Spent Fuel Pool area. The results indicate that the collective dose to the working crew of 13 would be 1.5 person-rem per NUHOMS cask transfer. A transfer cask load is approximately equal to the foreign research reactor spent nuclear fuel inventory of eight transportation casks.

IFSF (Dry Vault) Specific Dry Storage: Based on data provided by the Idaho National Engineering Laboratory, Table F-103 was generated to present the occupational dose for unloading one transportation cask into the IFSF. The collective dose to unload one transportation cask into the IFSF was calculated to be 0.32 person-rem. This dose is considered representative of a generic dry vault storage facility.

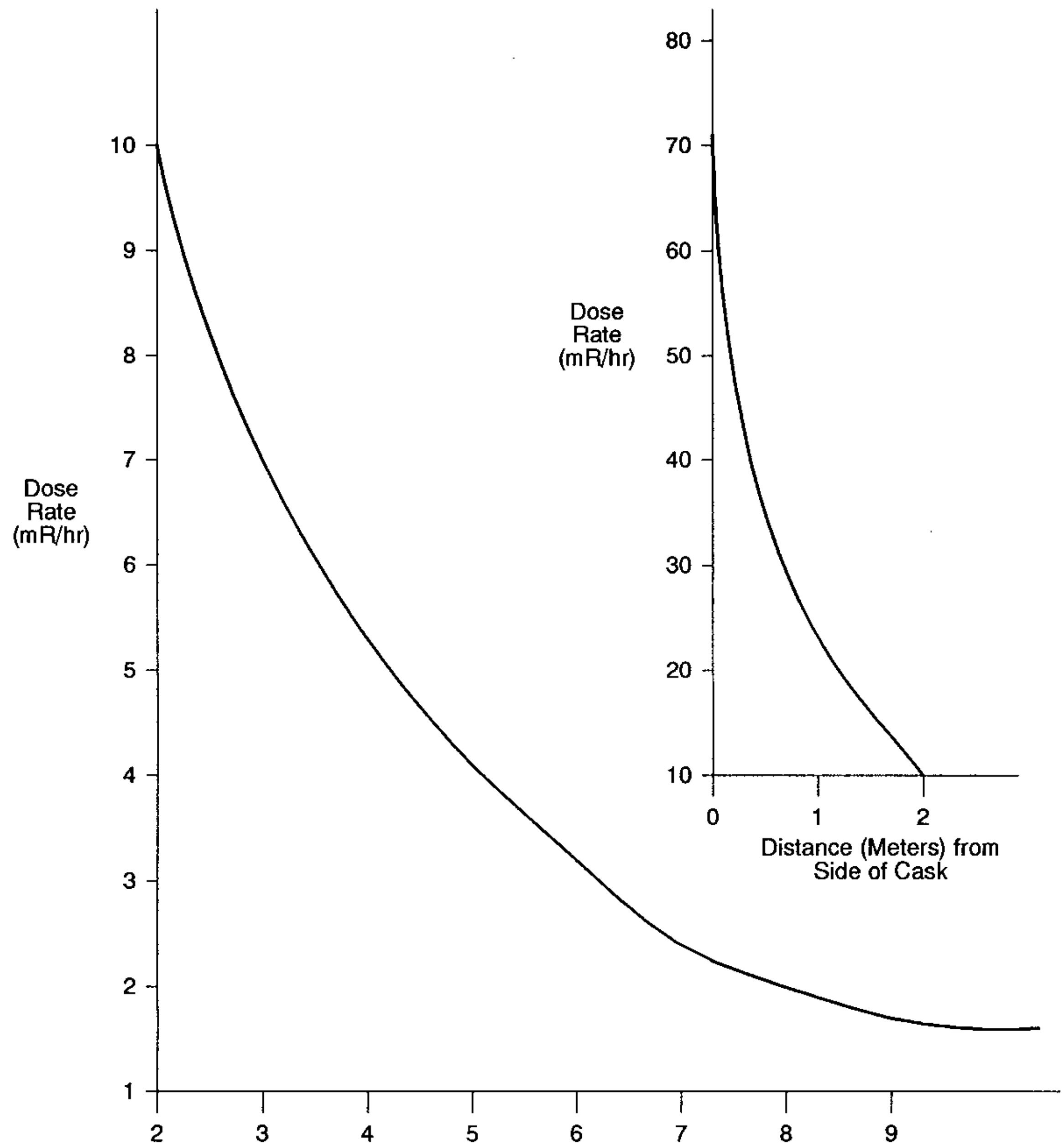

Figure F-50 Bounding Transportation Cask
(Dose Rate at a Distance Normalized to 10 millirem/hour at 2 meters [6.6 feet])

Table F-101 Actual Foreign Research Reactor Spent Nuclear Fuel Transportation Cask Dose Rate Measurements

Date	Cask Model	Fuel	Side Cask Measured Dose Rate (mrem/hr) at 1 m (3.3 ft)
Savannah River Site-Provided Data			
10/2/94	IU04-PEGASE		0.4
10/2/94	PEGASE		2.08
10/2/94	TN-7		8.4
10/2/94	GNS-11		1.2
12/18/87	PEGASE	DR3	1.5
1/26/89	PEGASE	DR3	0.6
12/31/87	PEGASE	ORPHEE	1.4
10/30/86	PEGASE	ORPHEE	0.5
9/1/87	PEGASE	SILOE	1.0
11/5/87	PEGASE	SILOE	0.3
12/30/87	PEGASE	SILOE	0.3
2/7/89	TN-7/2	RHF	15.0
8/16/88	TN-7/2	RHF	20.0
9/25/81	SWED.R2-B/23	AAR	0.9
1/20/89	TN-1	HFR	6.0
7/20/88	TN-1	HFR	0.5
6/8/88	GNS-11	FRJ-2	8.0
8/30/88	GNS-11	FRJ-2	0.8
8/30/88	GNS-11	FRJ-2	10.0
2/27/86	GOSLAR NO.1	FRG	2.0
11/12/86	GOSLAR NO.1	FRG	1.0
2/26/86	GOSLAR NO.2	FRG	0.2
3/10/80	GOSLAR NO.1	ASTRA	0.2
3/14/80	GOSLAR NO.2	ASTRA	0.1
1/29/86	BMI-1	RINC	0.5
2/6/86	BMI-1	RINC	0.4
6/5/84	BMI-1	U.VA.	0.5
6/11/84	BMI-1	U.VA.	0.5
9/11/84	BMI-1	U.MICH.	0.1
10/13/87	BMI-1	U.MICH.	0.1
7/14/81	BMI-1	U.MICH.	1.0
10/6/87	BMI-1	U.MICH.	0.1
Idaho National Engineering Laboratory-Provided Data			
	BMI-1	CORNELL-TRIGA	3.5
	BMI-1	BERKLEY-TRIGA	0.5
	BMI-1	MICHIGAN-TRIGA	1.0
	BMI-1	BERKLEY-TRIGA	0.5
	GE-700	BNL-HFBR	1.0
	GE-700	BNL-HFBR	1.0
	GE-700	BNL-HFBR	1.0
	GE-700	U. OF MISSOURI	0.1
	BMI-1	CORNELL-TRIGA	3.5
	BMI-1	MICHIGAN-TRIGA	0.1
	BMI-1	HANFORD-TRIGA	1.0
	BMI-1	HANFORD-TRIGA	1.0

Table F-102 Worker Dose Assessment for Receipt and Handling of Foreign Research Reactor Spent Nuclear Fuel in Wet Storage

Exposed Workers	*A.* *Exposure Distance (m)*	*B.* *Dose Rate (mrem/hr)*	*C.* *Exposure Time (minutes/cask)*	*D.* *Dose/Cask-Person (mrem)*	*E.* *Number of Exposed Workers*	*F.* *Collective Dose (Person-rem)*
Transport Receipt						
Shipping Agent	8.0	2.1	30	1.1E+00	1	1.1E-03
Subtotal			30	1.1E+00		1.1E-03
Health Physics Tech	1.0	23.0	5	1.9E+00	1	1.9E-03
	2.0	10.0	10	1.7E+00	1	1.7E-03
Subtotal			15	3.6E+00		3.6E-03
Guards	8.0	2.1	30	1.1E+00	1	1.1E-03
Subtotal			30	1.1E+00		1.1E-03
Remove Container Cover						
Foreman	10.0	1.5	20	5.0E+01	1	5.0E-04
	5.0	4.2	10	7.0E+01	1	7.0E-04
Subtotal			30	1.2E+00		1.2E-03
Operators	0.3	50.0	15	1.3E+01	3	3.8E-02
	0.3	50.0	10	8.3E+00	1	8.3E-03
	1.0	23.0	1	3.8E-01	1	3.8E-04
	2.0	10.0	10	1.7E+00	2	3.3E-03
Subtotal			36	2.3E+01		5.0E-02
Survey Cask						
Health Physics Tech	0.3	50.0	45	3.8E+01	1	3.8E-02
Subtotal			45	3.8E+01		3.8E-02
Removal of Impact Limiters						
Foreman	5.0	4.2	50	3.5E+00	1	3.5E-03
	2.0	10.0	10	1.7E+00	1	1.7E-03
Subtotal			60	5.2E+00		5.2E-03
Health Physics Tech	5.0	4.2	45	3.2E+00	1	3.2E-03
	0.3	50.0	15	1.3E+01	1	1.3E-02
Subtotal			60	1.6E+01		1.6E-02
Operators	0.3	50.0	10	8.3E+00	3	2.5E-02
	0.5	36.0	60	3.6E+01	2	7.2E-02
Subtotal			70	4.4E+01		9.7E-02
Move Cask						
Equipment Operators	0.3	50.0	5	4.2E+00	1	4.2E-03
Subtotal			5	4.2E+00		4.2E-03
Removal of Cask from Transport						
Foreman	8.00	2.1	45	1.6E+00	1	1.6E-03
	2.00	10.0	10	1.7E+00	1	1.7E-03
	1.00	23.0	5	1.9E+00	1	1.9E-03
Subtotal			60	5.2E+00		5.2E-03
Health Physics Tech	8.00	2.1	30	1.1E+00	1	1.1E-03
	2.00	10.0	20	3.3E+00	1	3.3E-03
	1.00	23.0	10	3.8E+00	1	3.8E-03
Subtotal			60	8.2E+00		8.2E-03
Equipment Operators	4.00	5.3	59	5.2E+00	2	1.0E-02
	1.00	23.0	1	3.8E-01	1	3.8E-04
Subtotal			60	5.6E+00		1.1E-02

Exposed Workers	A. Exposure Distance (m)	B. Dose Rate (mrem/hr)	C. Exposure Time (minutes/cask)	D. Dose/Cask-Person (mrem)	E. Number of Exposed Workers	F. Collective Dose (Person-rem)
Testing & Verification of Integrity						
Health Physics Tech	5.00	4.2	30	2.1E+00	1	2.1E-03
	2.00	10.0	28	4.7E+00	1	4.7E-03
	0.3	50.0	2	1.7E+00	1	1.7E-03
Subtotal			60	8.4E+00		8.4E-03
Operators	0.30	50.0	30	2.5E+01	2	5.0E-02
	4.00	5.3	30	2.7E+00	2	5.3E-03
Subtotal			60	2.8E+01		5.5E-02
Movement of Cask to Unloading Pool and Immersion						
Operators	0.30	50.0	2	1.7E+00	3	5.0E-03
	NA	0.1	58	9.7E-02	2	1.9E-04
Subtotal			60	1.8E+00		5.2E-03
Cask Unloading/Inspection/Storage						
Foreman	NA	0.1	240	4.0E-01	1	4.0E-04
Subtotal			240	4.0E-01		4.0E-04
Safeguards	NA	0.1	240	4.0E-01	1	4.0E-04
Subtotal			240	4.0E-01		4.0E-04
Operators	NA	0.1	240	4.0E-01	5	2.0E-03
Subtotal			240	4.0E-01		2.0E-03
Removal of Cask from Unloading Pool						
Operators	NA	0.1	60	1.0E-01	2	2.0E-04
Subtotal			60	1.0E-01		2.0E-04
Replacement of Cask of Transport and all subsequent operators assumed to be no exposure greater than background						
	NA	0.0	90	0	5	0
Subtotal				0		0
Total				**4.4E+01 (Max.)**		**3.1E-01**

Table F-103 Worker Dose Assessment for Receipt and Handling of Foreign Research Reactor Spent Nuclear Fuel in a Dry Storage Facility (Irradiated Fuel Storage Facility) or Generic Vault

Exposed Workers	A. Exposure Distance (m)	B. Dose Rate (mrem/hr)	C. Exposure Time (minutes/cask)	D. Dose/Cask-Person (mrem)	E. Number of Exposed Workers	F. Collective Dose (Person-rem)
Transport Receipt						
Shipping Agent	8.0	2.1	30	1.1E+00	1	1.1E-03
Subtotal			30	1.1E+00		1.1E-03
Health Physics Tech	1.0	23.0	5	1.9E+00	1	1.9E-03
	2.0	10.0	10	1.7E+00	1	1.7E-03
Subtotal			15	3.6E+00		3.6E-03
Guards	8.0	2.1	30	1.1E+00	1	1.1E-03
Subtotal			30	1.1E+00	1	1.1E-03
Remove Container Cover						
Foreman	10.0	1.5	20	5.0E-01	1	5.0E-04
	6.0	1.2	10	7.0E-01	1	7.0E-04
Subtotal			30	1.2E+00		1.2E-03
Operators	0.3	50.0	15	1.3E+01	3	3.8E-02
	0.3	50.0	10	8.3E+00	1	8.3E-03

Exposed Workers	A. Exposure Distance (m)	B. Dose Rate (mrem/hr)	C. Exposure Time (minutes/cask)	D. Dose/Cask-Person (mrem)	E. Number of Exposed Workers	F. Collective Dose (Person-rem)
	1.0	23.0	1	3.8E-01	1	3.8E-04
	2.0	10.0	10	1.7E+00	2	3.3E-03
Subtotal			36	2.3E+01		5.0E-02
Survey Cask						
Health Physics Tech	0.3	50.0	45	3.8E+01	1	3.8E-02
Subtotal			45	3.8E+01		3.8E-02
Removal of Impact Limiters						
Foreman	5.0	4.2	50	3.5E+00	1	3.5E-03
	2.0	10.0	10	1.7E+00	1	1.7E-03
Subtotal			60	5.2E+00		5.2E-03
Health Physics Tech	5.0	4.2	45	3.2E+00	1	3.2E-03
	0.3	50.0	15	1.3E+01	1	1.3E-02
Subtotal			60	1.6E+01		1.6E-02
Operators	0.3	50.0	10	8.3E+00	3	2.5E-02
	0.5	36.0	60	3.6E+01	2	7.2E-02
Subtotal			70	4.4E+01		9.7E-02
Removal of Cask from Transport to Transfer Cart						
Foreman	8.0	2.1	45	1.6E+00	1	1.6E-03
	2.0	10.0	10	1.7E+00	1	1.7E-03
	1.0	23.0	5	1.9E+00	1	1.9E-03
Subtotal			60	5.2E+00		5.2E-03
Health Physics Tech	8.00	2.1	30	1.1E+00	1	1.1E-03
	2.00	10.0	20	3.3E+00	1	3.3E-03
	1.00	23.0	10	3.8E+00	1	3.8E-03
Subtotal			80	8.2E+00		8.2E-03
Equipment Operators	4.00	5.3	59	5.2E+00	2	1.0E02
	1.00	23.0	1	3.8E-01	1	3.8E-04
Subtotal			60	5.6E+00		1.1E-02
Testing & Verification of Integrity, Lid Bolt Removal						
Foreman	4.00	5.3	60	5.3E+00	1	5.3E-03
Subtotal			60	5.3E+00		5.3E-03
Health Physics Tech	5.00	4.2	30	2.1E+00	1	2.1E-03
	2.00	10.0	28	4.7E+00	1	4.7E-03
	0.30	50.0	2	1.7E+00	1	1.7E-03
Subtotal			60	8.4E+00		8.4E-03
Operators	0.30	50.0	30	2.5E+01	2	5.0E-02
	4.00	5.3	30	2.7E+00	2	5.3E-03
Subtotal			60	2.8E+01		5.5E-02
Movement of Cask into Handling Cove						
Foreman	4.00	5.3	60	5.3E+00	1	5.3E-03
Subtotal			60	5.3E+00		5.3E-03
Operators	4.0	5.3	10	8.8E-01	2	1.8E-03
	NA	0.1	50	8.3E-02	2	1.7E-04
Subtotal			60	9.7E-01		1.9E-03
Cask Unloading/Inspection/Storage						
Foreman	NA	0.1	480	8.0E-01	1	8.0E-04
Subtotal			480	8.0E-01		8.0E-04
QA Inspector	NA	0.1	480	8.0E-01	1	8.0E-04
Subtotal			480	8.0E-01		8.0E-04

Exposed Workers	A. Exposure Distance (m)	B. Dose Rate (mrem/hr)	C. Exposure Time (minutes/cask)	D. Dose/Cask-Person (mrem)	E. Number of Exposed Workers	F. Collective Dose (Person-rem)
Operators	NA	0.1	480	8.0E-01	2	1.6E-03
Subtotal			480	8.0E-01		1.6E-03
Removal of Cask from Handling Cove						
Foreman	NA	0.1	60	1.0E-01	1	1.0E-04
Subtotal			60	1.0E-01		1.0E-04
Operators	NA	0.1	60	1.0E-01	2	2.0E-04
Subtotal			60	1.0E-01		2.0E-04
Replacement of Cask of Transport and All Subsequent Operators Assumed to be No Exposure Greater than Background	NA	0.0	90	0	5	0
Subtotal			90	0		0
Total				**4.4E+01 (Max.)**		**3.2E-01**

DSC = Dry Shielded Canister

Transfer Between Storage Facilities: The collective doses were calculated for loading fuel into a pod, a dry vault (i.e., the IFSF), and dry cask (i.e., Calvert Cliffs NUHOMS) or during transfer between these facilities. It was assumed that larger commercial spent nuclear fuel transportation casks are used for intersite and intrasite movement of foreign research reactor spent nuclear fuel within the United States. Their capacity is approximately four times that of the foreign research reactor spent nuclear fuel transportation casks from overseas. It was also assumed that the transfer cask for the dry cask design has a capacity which is approximately eight times that of the overseas foreign research reactor spent nuclear fuel transportation casks.

F.6 Evaluation Methodologies and Assumptions for Incident-Free Operations and Hypothetical Accidents at Management Sites

Appendix F.6 describes only the methodologies and assumptions used for estimating radiation exposure (doses) to individuals and the general public from releases of radioactivity during incident-free operations and hypothetical accidents at potential management sites. The descriptions of similar evaluations for ground and marine transportation and port accidents are documented in Appendix E and Appendix D.

F.6.1 Analysis Methods for Evaluation of Radiation Exposure

F.6.1.1 General

An evaluation of incident-free operations and hypothetical accidental radioactive material releases at the proposed storage sites was performed to assess the impact of possible radiation exposure to individuals and the general population. The analysis assumes that the same operations are being carried out at different potential storage locations. The impact of the same radioactive material releases was evaluated at all potential sites. This approach provides a consistent method for comparing the effects of the proposed alternative actions.

F.6.1.2 Exposure Impacts to Be Estimated

The impact of radiation exposure (dose) to the following individuals and the general population is calculated for incident-free operation of the spent nuclear fuel storage facility and for accident conditions:

- ***Worker:*** An individual located 100 m (330 ft) from the radioactive material release point.[2] The dose to the worker is calculated for the 50th-percentile meteorology only (DOE, 1992a).

- ***MEI:*** A theoretical individual living at the storage site boundary and receiving the maximum exposure.

- ***NPAI:*** At some storage sites, highways used by the public may cross the Federal reservation where foreign research reactor spent nuclear fuel operations could be conducted. Consequently, these analyses included evaluation of the exposure to a theoretical motorist who might be stranded on such a highway at the time of an accident. Based on experience from emergency exercises, emergency response teams would be able to evacuate such an individual within 2 hours, so this was the exposure time used in the calculations.

- ***General population*** within an 80 km (50 mi) radius of the facility.

The doses to the NPAI, MEI and general population are calculated for the 50th- and 95th-percentile meteorological conditions. The details of exposure times for MEI, NPAI, worker, and general public are given in Section F.6.4.1.

The radiation dose to individuals and the public resulting from exposure to radioactive contamination was calculated using the following potential pathways:

- external direct exposure from immersion in the airborne radioactive material (air immersion),

- external direct exposure from radioactive material deposited on the ground (ground surface),

- internal exposure from inhalation of radioactive aerosols and suspended particles (inhalation), and

- internal exposure from ingestion of contaminated terrestrial food and animal products (ingestion).

The radiation dose is estimated by the GENII (Version 1.485) computer program (Napier et al., 1988) in a manner recommended by the International Commission on Radiological Protection in Publications 26 and 30 (ICRP, 1977; ICRP, 1979-1982). Committed dose equivalents [3] are calculated for organs such as the gonads, breasts, red bone marrow, lungs, thyroid, bone surface, liver, lower large intestine, upper large

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2 *For elevated release, the worker dose was calculated at a point of maximum dose. The distance at which the maximum dose occurs is frequently greater than 100 m (300 ft) for elevated release.*

3 *The definitions of committed dose equivalents, committed effective dose equivalents, and total effective dose equivalents are consistent with those given in 10 CFR Part 835, "Occupational Radiation Protection; Final Rule," (DOE, 1993a).*

intestine, small intestine, and stomach. Weighting factors are used for various body organs to calculate weighted or committed effective dose equivalent (EDE) from radiation inside the body due to inhalation or ingestion. The committed EDE value is the summation of the committed dose equivalent to the specific organ weighted by the relative risk to that organ compared to an equivalent whole-body exposure.

The program also estimates deep-dose equivalent for the external exposure pathways (immersion in the radioactive material and exposure to ground contamination) and a 50-year committed EDE for the internal exposure pathways. The sum of the deep-dose equivalent for external pathways and the committed EDE for internal pathways is called the cumulative dose or "total EDE" in this EIS and is also estimated by the GENII program.

The exposure from ingestion of contaminated terrestrial food and animal products is calculated on a yearly basis. However, it is expected that continued consumption of contaminated food products by the public would be suspended if the projected dose exceeds the protective action guidelines for use in the event of radiological accidents (EPA, 1991). No reduction of exposure due to protective actions was accounted for in this analysis, however. This results in a conservative approach that may overestimate health effects within an exposed population, but allows for consistent comparisons between alternatives.

F.6.1.3 Evaluation of Health Effects

Health effects are calculated from the exposure results. The risk factors used for calculations of health effects are taken from International Commission on Radiological Protection Publication 60 (ICRP, 1991) (see Table F-104). From this list only the factors associated with the fatal cancers were used in the analysis. Other factors are given as additional information for completeness.

Table F-104 Risk Estimators for Health Effects from Ionizing Radiation

Effect	*Risk Factor (probability/rem)*[a]	
	Worker	*General Population*
Fatal cancer (all organs)	4.0×10^{-4}	5.0×10^{-4}
Weighted nonfatal cancer[b]	8.0×10^{-5}	1.0×10^{-4}
Weighted genetic effects[b]	8.0×10^{-5}	1.3×10^{-4}

[a] *For high individual exposures (20 rem), the risk factors are multiplied by a factor of two.*

[b] *In determining a means of assessing health effects from radiation exposure, the International Commission on Radiological Protection has developed a weighting method for nonfatal cancers and genetic effects. These factors are provided here for information only and were not used in this analysis. Genetic effects can only be applied to population, not to individuals.*

F.6.1.4 Population

Population distributions specific to each site were used for the evaluations. The population distributions were obtained from each site. The population information was obtained in 16 compass directions and 10 radial distances from the likely location of a foreign research reactor spent nuclear fuel storage facility to an 80 km (50 mi) total distance.

F.6.1.5 Meteorology

Meteorology specific to each site was used in the evaluation. The site-specific meteorological data was prepared, or acquired from each candidate storage site, in the form of joint frequency distribution in terms of percentage of time that the wind blows in specific directions (i.e., south, south-southwest, southwest, etc.) for the given midpoint (or average) wind speed class and atmospheric stability. Accident consequence calculations were performed using 50th- and 95th-percentile meteorological conditions. The 50th-percentile condition represents the median meteorological condition, and is defined as that for which more severe conditions occur 50 percent of the time. The 95th-percentile condition represents relatively low probability meteorological conditions which produce higher calculated exposures, and is defined as that condition which is not exceeded more than 5 percent of the time. GENII determines 50th- and 95th-percentile meteorological conditions using site-specific joint frequency distribution weather data.

F.6.1.6 Computer Programs

The following computer programs were used to evaluate the radiation exposure to the specified individuals and the general population.

GENII: The GENII code (Napier et al., 1988) was used to model both acute and chronic releases to the atmosphere. This code was developed by the Pacific Northwest Laboratory to incorporate the internal dosimetry models recommended in International Commission on Radiological Protection Publication 26 (ICRP, 1977) and Publication 30 (ICRP, 1979-1982) into environmental pathway analysis models in use at the Pacific Northwest Laboratory. This code has been used by the Pacific Northwest Laboratory and other laboratories in site-wide dosimetry calculations. It has been extensively validated and quality assured.

ORIGEN2: ORIGEN2 (Croff, 1980) is a computer code system for calculating the buildup and decay of radioactive materials (fission products, actinides, and activation products). The code input was modeled to describe the HEU and low enriched uranium (LEU) research reactor nuclear fuel system and used neutronic cross-section data that are distinct to these fuels. ORIGEN2 has been used extensively by the Argonne National Laboratory in the RERTR program in estimating nuclide inventories of irradiated fuels. The code and the specific neutronic cross-section parameters for HEU and LEU fuels were acquired from the Argonne National Laboratory. ORIGEN2 is widely used and accepted throughout the nuclear industry.

F.6.2 Screening/Selection of Accidents for Detailed Examination

Accidents considered for inclusion in the detailed analyses are similar to those analyzed in the Programmatic SNF&INEL Final EIS for the spent nuclear fuel storage facility operations (DOE, 1995g). The analyzed accident scenarios in the Programmatic SNF&INEL Final EIS for each potential storage site were reviewed to identify the bounding accidents to be considered in this EIS. The review included accidents initiated by natural phenomena (earthquakes, tornadoes, hurricanes, etc.) and accidents initiated from human or equipment failure (fires, explosions, aircraft crashes, transportation accidents, and terrorism).

A review of accidents indicates that only severe accident conditions could result in a release of radioactive material to the environment or an increase in radiation levels. Some types of accidents, such as procedure violations, spills of small volumes of water containing radioactive particles, and most other types of common human error may occur more frequently than the more severe accidents analyzed. However, these accidents do not involve enough radioactive material or radiation to result in a significant release to the environment or a meaningful increase in radiation levels. Stated another way, the very low consequences associated with these events produce smaller risks than those for the accidents analyzed, even when combined with a higher probability of occurrence. Consequently, they have not been included in the results presented in this EIS.

Accidents initiated at nearby facilities, either by other activities unrelated to spent nuclear fuel handling or storage or during construction of a wet or dry storage facility, would not produce effects more severe than the sequence of events being analyzed. This is because foreign research reactor spent nuclear fuel undergoing examination or in the process of being stored would not need special conditions or uninterrupted operator attention to prevent overheating or to maintain containment or shielding. Therefore, evacuation in response to an accident at some other facility would not compromise integrity of the spent nuclear fuel.

The potential for common-cause accidents at a storage facility has been considered. It is possible for natural phenomena, like an earthquake, to produce more than one accident at a site causing a situation that results in a release of radioactive material into the atmosphere or an increase in radiation levels due to loss of shielding. However, the probability of two or more accidents having maximum consequences occurring concurrently is less than the probability of the individual events. For example, if an earthquake affected the wet storage facility, a crane might fail causing damage to stored spent nuclear fuel, and the water pool might drain. The impacts for this could be conservatively estimated by summing the consequences. Similarly, consequences from spent nuclear fuel facilities within a DOE site could be combined to conservatively estimate site-wide impacts. But again, the probability of a common-cause event resulting in this number of consequences is lower than the probability of individual accidents because, due to separation distances, the severity of impact will vary between facilities. The existing security measures in effect at the management sites would essentially preclude any sabotage or terrorist activity. Further, any acts of terrorism are expected to result in consequences which are bounded by the results of accidents analyzed. Thus, no specific analyses of the results of terrorist acts were conducted.

Based on the above, the review identified the following bounding accident scenarios:

- criticality caused by human error during operation, equipment failure, or earthquake;
- mechanical damage to foreign research reactor spent nuclear fuel during examination and preparation (cropping off the aluminum and nonfuel end of a fuel); and
- accident involving an impact by either an internal or external initiator with and without an ensuing fire.

F.6.3 Accident Scenarios Considered

A total of six bounding accident scenarios for the handling and storage of foreign research reactor spent nuclear fuel were identified for detailed analysis. Each of these accident scenarios was evaluated at each storage location using identical source terms. As described below, three of the bounding accident scenarios apply to wet storage and three apply to dry storage.

F.6.3.1 Wet Storage Bounding Accident Scenarios

Three hypothetical accident scenarios were evaluated for foreign research reactor spent nuclear fuel stored in water pools: (a) fuel element breach (i.e., cutting into the fuel region) or mechanical damage due to operator error, (b) an accidental criticality, and (c) an aircraft crash into the water pool facility. In addition to these three scenarios, a dropped fuel cask was also considered to be a foreseeable accident. However, as will be seen in Section F.6.4.4.4, the consequences of this accident are bounded by the cutting into a fuel region scenario. Therefore, a dropped fuel cask was not evaluated in detail.